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SURGICAL

DIAGNOSIS AND TREATMENT

BY AMERICAN AUTHORS

EDITED BY

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DISEASES AND INJURIES OF THE JEJUNO-ILEUM AND ITS MESENTERY.

By JOHN TAYLOR BOTTOMLEY, M.D., LL.D.

Much of the duodenum has the same embryonic origin (the foregut) as the stomach and duodenal disease finds its expression in a syndrome so closely resembling that of gastric disease that one is often not clearly to be distinguished from the other; it is fitting therefore that affections of both organs should be considered together.

The true small intestine—intestinum mesenteriale—is derived from the midgut. It is the freely movable portion of the small intestine, being suspended from the posterior abdominal wall by a mesentery, between the leaves of which the bloodvessels, the lymphatics and the nerves run to or from the intestinal tube. It has a length of about twenty-one feet and is commonly divided into an upper two-fifths, the jejunum, and a lower three-fifths, the ileum. This division, however, is rather arbitrary, for between the two portions there is no marked line of demarcation, the jejunum gradually and imperceptibly becoming ileum.

CONGENITAL DEFECTS AND MALFORMATIONS.

Various theories have been advanced to account for the existence of these congenital defects which are found in a proportion of from 1 to 16,000 to 1 to 55,000 infants. Kreuter and others[1] believe that the most common defect, atresia, is due to suspension of the process of canalization of the solid intestinal cord which exists in the early fetal life of vertebrates. A causal relation is also attributed to accidents or anomalies in vascularization. In Spriggs'[2] opinion no one theory can explain all the cases and he sums up the causes thus in order of frequency:

1. Developmental defects, particularly in connection with the vitelline duct.
2. Fetal accidents, *i. e.*, intussusceptions, volvuli, kinks, etc.
3. Fetal diseases, *i. e.*, peritonitis, intestinal ulceration, etc.

Whatever the cause may be, almost all congenital defects in the jejuno-ileum have to do with a complete closure (the intestine ending in a blind sac), with an extensive narrowing or with an entire absence of a portion or portions of the intestine. They are usually single, occasionally multiple and are far less common in the jejunum than in the ileum, occurring most frequently in the vicinity of the attachment

[1] Rowland: Am. Jour. Dis. of Children, 1915, No. 5, ix.
[2] Guy's Hosp. Rep., 1912, lxvi, 143-218.

of the vitelline duct. In Spriggs' series, 60 per cent. of the cases were within one foot of the ileocecal valve. The occlusion is most often complete. Sometimes the obstruction exists in the form of a muco-muscular diaphragm or membrane (which may be perforated or imperforate) stretched across the lumen of the intestines — the so-called "septate" ileum. The intestine externally may give no indication of the location of this diaphragm which may be so well-developed as to close the lumen completely or so rudimentary as to offer no appreciable hindrance to the passage of the fecal stream.

Symptoms and Diagnosis.—The symptoms are those of obstruction. Vomiting is a constant and early symptom, usually beginning by the second day; nevertheless, the infant may nurse well. Though absolute constipation from birth is the rule, yet what appears to be normal meconium may be passed at first, even in cases of complete obstruction. It is likely, however, that such bowel movements are composed of altered blood or of a greenish mucoid substance and not of meconium. Some degree of distention occurs nearly always and in rare cases may be present at birth. Visible peristalsis is sometimes seen. Free peritoneal fluid may or may not be present. Jaundice, anuria and convulsions are occasional symptoms.

Little is to be gained through attempts to determine the location of the obstruction. The pressing need is to decide whether or not an obstruction is present anywhere and, if the evidence seems affirmative, to rule out, first of all, a rectal atresia or imperforate anus which are the most common congenital defects. With that object in view the anal region should be carefully inspected. The absence of the anal depression speaks for itself. If the depression is present, a thorough examination of the canal with a small bougie or with the little finger should be made. Bear in mind that a rectal atresia, when it exists, is almost without exception within two inches of the anus and that the bulging, distended bowel-end above it may be palpated by the examining finger, especially when the child cries. If, then, the bougie can be passed beyond a point more than two inches above the anal opening, a rectal atresia may be ruled out. Thorough examination is very desirable and bougies of gradually increasing size should be used until the canal is dilated sufficiently to permit insertion of the little finger. A very considerable resistance in the rectum may be due not to a true rectal atresia but to a contracted, undeveloped state of the bowel consequent upon true occlusion at a much higher level. This condition explains why only a small amount (not more than 1 to 2 ounces) of fluid can be injected into these cases and why if, after repeated enemata, only almost colorless mucus be returned, a diagnosis of intestinal occlusion may be made. After twenty-four to thirty-six hours, if no meconium is evacuated even when the bowel is flushed, the diagnosis may be assumed, especially in the presence of other characteristic symptoms of obstruction.

Prognosis.—This may be put down as absolutely bad. Up to 1912, at least 82 cases had been submitted to operation without a single

recovery. The condition occurs in subjects who are poor surgical risks and it is frequently incompatible with life. While postmortem examination has occasionally disclosed conditions which could have been remedied by surgery, yet in the few cases, which surgical measures could possibly help, the establishment of a diagnosis is surrounded by so many difficulties that it is usually reached too late to be of practical benefit. Our only hope for better results lies in the making of a more prompt diagnosis, even if exploratory laparotomy must be employed as a means. The prognosis, however, must always remain grave because of the age of the patient, the severity of the operation and the usual low state of nutrition of the subject.

Treatment.—Operation, if undertaken at all, should be done just as soon as a probable diagnosis has been made. Spriggs advises the employment of spinal anesthesia but personally I should prefer to rely on ether. The inoperability of some cases will be evident as soon as the abdomen is opened; in others, conditions may be less hopeless. If there is a simple complete block in the lower ileum, dilate by water pressure the contracted bowel below it and do a lateral intestinal anastomosis (Spriggs). A portion of gut containing multiple strictures may be entirely cut out of the intestinal circuit. Rectal implantation may be considered. In desperate cases enterostomy has been done.

Diverticula (Other than Meckel's) of the Jejuno-ileum.—In this portion of the tract, diverticula are usually situated close to the insertion of the mesentery and to the left of it. They are almost always multiple but occasionally a single diverticulum is seen; they vary in size in inverse ratio to their number.[1] They are most frequent in the ileocecal region but may occur anywhere in the small intestine. It may be said that practically all are congenital in origin, though mechanical and inflammatory factors may have some effect in their development and its direction. While anatomically interesting, they are rarely of any surgical concern and I can find but one recorded case of clinical significance in the causation of which they played a part. Gordonier and Sampson[2] report a case of partial intestinal obstruction due to kinking of the small intestine which was secondary to a mesenteritis, the infection originating in an inflamed, occluded diverticulum. A tender mass could be felt before the operation which disclosed the connection between the pathological condition and the diverticulum. This case is, as far as I know, unique. It may be safely assumed, I believe, that diverticula give no recognizable signs of their presence and are discovered only at autopsy or during the course of an operation. Walker,[3] for instance, in operating for the removal of an appendix in a girl of twelve years, found in close proximity to the field three diverticula of the ileum; one was as large as the thumb of an adult and contained fecal material. In surgical case No. 3950 at the Carney Hospital, during the making of a gastro-enterostomy, a small diverticulum of the jejnnum was found a few inches from the duodenojejunal angle

[1] Latarjet and Murard, J.: Lyon Chir., 1914, xi, No. 5.
[2] Jour. Am. Med. Assn., 1906, xlvi, No. 21.
[3] Ibid., 1912, lviii, No. 16.

and near the upper side of the mesenteric border. Though it had caused no symptoms, it was excised.

The *treatment* is removal, which is usually easily accomplished.

Meckel's Diverticulum.—As far as the small intestine is concerned the only diverticulum of much surgical interest is that of Meckel, which is usually situated two or three feet above the ileocecal valve and projects like a glove finger from the small intestine almost always opposite the mesentery. Its usual length is about 3 inches, the recorded extremes being less than 1 inch and 8 inches. Its diameter is that of the intestine from which it springs or slightly less. It is present in 1 to 2 per cent. of all bodies but a more practical measure of its frequency is supplied by the fact that in 10,600 abdominal operations at the Mayo Clinic from 1908 to 1911, it was met fifteen times.[1] In only 5 of these cases did it produce symptoms for which the patient sought relief.

The anomaly may be complete and form a cylindrical tube opening at the umbilicus and into the intestine—a fecal fistula. More commonly, however, only a portion remains and it persists as a free diverticulum which opens into the intestine. Examples are known of all stages between these extremes. Eisendrath (quoted by Drummond[2]) has seen a case in which the remnant had a communication neither with the umbilicus nor with the intestine and had formed, through retaining its own secretion, a large cystic tumor. Granuloma, polyp and carcinoma of the navel have been known to originate in its remains or to occur as a result of its persistence.

Having in most instances the same coats as the appendix, it is susceptible to similar pathological changes (inflammation, perforation, etc.). However, the chief danger arising from its presence is its tendency to cause intestinal obstruction, 5 to 6 per cent. of all cases of the latter being due to it. (J. B. Murphy.)

A mechanical obstruction may be caused by a free diverticulum or by an adherent one.[3] Obstruction caused by a free diverticulum is far less common. It is seen most frequently in the form of an invagination of the diverticulum into the intestinal lumen and the obstruction may be due to that factor alone or to a resultant intussusception. Occasionally, obstruction follows strangulation of a diverticulum in a hernial sac into which it has made its way.

An adherent diverticulum may be attached to the mesentery—its most frequent point of attachment—to the umbilicus or elsewhere on the abdominal wall, or to the intestine itself by a fibrous cord or thread which represents the more or less atrophic omphalomesenteric vessels or may be the result of a previous diverticulitis. The possible subsequent obstruction may occur by direct traction on and kinking of the parent coil, by torsion and knotting of that or of another coil, by twisting of the mesentery or through the encircling or compressive action of the diverticulum itself.

[1] Balfour: Jour. Minnesota State Med. Assn., March 1, 1911.
[2] Ann. Surg., 1912, lv, No. 3.
[3] Colson: Jour. de Chir. et Annales de la Soc. Belge de Chir., 1914, xxii, No. 3.

The symptoms of the obstruction are not particularly unlike those of obstruction from other causes and these will be considered later.

An acute abdominal crisis due to Meckel's diverticulum is relatively not uncommon. While infancy and adolescence are particularly susceptible periods, it is worthy of mention that in Porter's[1] collected series, six patients were over fifty years old and the average age was twenty-one years and two months. The male sex is affected three times as frequently as the female. The pressure of a foreign body (fecal concretion, etc.) in the diverticulum is often an exciting cause.

Symptoms.—The symptoms of a diverticulitis are very similar to those of inflammation of the appendix. The localization of the colicky pain at or near the umbilicus arouses our suspicions but it is by no means pathognomonic. The diverticulitis may be the immediate cause of intestinal obstruction and Colson even questions whether some of the cases of obstruction seemingly caused by an adherent diverticulum may not really have been secondary to an inflammatory process in a once free diverticulum which had become adherent.

The inflammatory process may result in perforation or may subside only to again flare up at a later period. It may complicate the post-operative course of a drained appendix abscess as in a case in my own experience. The appendix had been removed at the primary operation and the abscess had been drained but it was only at a third operation a month later that the cause of recurrent attacks of pain in the region of the operation was found and removed in the inflamed, adherent diverticulum.

Diagnosis.—The diagnosis is seldom made before operation but an exact diagnosis is not at all necessary. The important thing is to recognize that there is present an abdominal condition which demands prompt surgical action and to remember that such a structure as Meckel's may exist and may cause such a condition. In the vast majority of cases the trouble manifests itself as a peritonitis or as an obstruction with or without strangulation (Porter). In case the diverticulum contains a foreign body the efforts of the structure to expel it may give rise to attacks of pain simulating biliary or appendicular colic.

The history of bleeding from the umbilicus in infancy or the presence of any abnormality in the umbilical region should suggest the possibility of a Meckel's being present. The existence of other congenital deformities (hare-lip, etc.), has proved of no particular diagnostic value.

Prognosis.—If one may judge from statistics, the prognosis is grave. Of course, the mere uncomplicated excision of a diverticulum carries no mortality but the treatment of the secondary conditions that may arise from a diseased diverticulum may demand all the surgical skill that the best surgeon possesses. The more prompt the surgical interference, the better is the prognosis. If the surgeon will keep in mind the possibility of a diverticulum as a factor in obscure conditions having to

[1] Jour. Am. Med. Assn., 1905, xlv, No. 13.

do with the small intestine, a long step will have been taken in the direction of early diagnosis.

Treatment.—If in the course of an operation for any intra-abdominal trouble one meets with a Meckel's diverticulum, it should be entirely excised and the opening into the intestine closed by a seromuscular suture after the bleeding has been checked. The diverticulum may be crushed close to its insertion into the intestine, ligated in the line of the crush and the distal portion removed. The small stump may then be invaginated into the intestinal canal by a purse-string suture. When a diverticulum is itself the cause of abdominal symptoms, the existing condition must be treated according to its nature, whether it be a diverticulitis, a perforation or an obstruction. It is well to remember that a diverticulum may so closely resemble the small intestine itself as to be distinguished from it even at operation only by close observation.

Developmental Defects and Irregularities in General.—These are usually of academic interest only. Their possible causal relation with Lane's kink, Jackson's membrane and other bands and adhesions in the ileocecal region has been the subject of much study and speculation which have as yet given no clearly defined practical results. Occasionally, however, they give rise to serious trouble even late in life. Twyman[1] reports a fatal case of intestinal obstruction in a man of fifty-four years, which was due to a non-rotated ileum, to the terminal coil of which the overriding ascending colon had become adherent. Similar instances are fortunately rare.

FOREIGN BODIES IN THE SMALL INTESTINE.

It is only rarely that a foreign body in the small intestine indicates its presence by symptoms. Manifestly, only such as have difficulty in passing along the intestine and act as an impediment to the fecal current are of clinical interest and these give rise either to colic consequent upon the effort of the intestinal musculature to move the foreign body along the tract, to symptoms of more or less complete obstruction or, very infrequently, to those of a peritonitis following the perforation of a pressure ulcer. A gall-stone which has ulcerated through into the small intestine from the gall-bladder figures most often as the foreign body but infrequent cases of trouble from a retained Murphy button or a hair-ball or false teeth or an enterolith have been reported.[2] The matter of diagnosis will be considered later. (Under Ileus.)

INJURY OF THE SMALL INTESTINE.

This may be an accompaniment of a penetrating wound of the abdominal wall or it may take place subcutaneously through the action of a blunt force, which may leave little or no external sign of violence.

[1] Jour. Am. Med. Assn., 1918, lxx, No. 10.
[2] Lanz: Lehrbuch der Chirurgie, Wullstein und Wilms, Jena, 1914, ii, 108.

As a matter of fact, little need be said of the symptoms and diagnosis of penetrating wounds of the abdomen nor need there be any clinical distinction made between them and the so-called "perforating" injuries. For our purpose they may be regarded as identical. It is generally agreed that there are no symptoms that warrant our deciding in doubtful cases that an abdominal wound is or is not penetrating. The history of the accident, the character of the weapon used and the relative position of the participants may occasionally be such as to determine at once that the injury is or is not serious; but in any case at all doubtful (and practically all cases fall within this category), an early decision as to whether a given wound is penetrating or non-penetrating, perforating or non-perforating, is so much a matter of chance, is so absolutely uncertain, is surrounded by so many difficulties and, if wrong, is followed by such grave results that the only safe method of procedure even in the absence of alarming symptoms is to sterilize the neighborhood of the external wound with tincture of iodin, apply a clean dressing, convey (if in any way possible) the patient to a hospital and do an immediate laparotomy. The actual conditions thus disclosed will indicate the proper measures for adoption.

Gunshot Wounds.—It is in some ways unfortunate that so few surgeons in civil life have had a wide experience in this field, where experience is the only reliable teacher. It is a fact that a gunshot wound of the abdomen is a rarity in the practice of most surgeons. It follows then that our rules of procedure must be based upon the advice of those to whom experience has come and, of course, upon the principles that underlie abdominal surgery in general.

The small intestine is more frequently injured than any other intra-abdominal organ and is said to be perforated in 65 per cent. of the cases.[1] Exceptionally, it may escape injury in a most marvelous way from a bullet traversing the abdominal cavity in an antero-posterior direction but Lagarde lays down as a rule that bullets passing through the cavity in a transverse or oblique direction cause multiple perforations of the small intestine in the vast majority of cases. Multiple perforations are far more common than single. As many as twenty-eight perforations of the small intestine in a single case have been noted. The mesentery, too, is not infrequently injured.

Most of this class of wounds seen in civil hospitals are due to pistol or revolver shots. Even in these weapons, this is the day of steel-jacketed bullets of high velocity; usually the weapon is used at close range and the damage done is correspondingly great. Many cases are doomed to speedy death from the moment they are shot.

Symptoms.—As a rule there are no pathognomonic symptoms. In early cases shock is usually but not always present. It is noticeably less marked in the colored race. Prolonged and persistent shock means a serious injury and is often the expression of severe hemorrhage which is further indicated by its more common signs (shifting dulness

[1] Lagarde: Gunshot Injuries, New York, 1914.

in the flanks, pallor, restlessness, thirst, nearly imperceptible pulse of low tension, air-hunger, shallow respiration, etc.). Bloody stools mean damage to the intestinal tract; in injury to the small intestine the color is more likely to be a dark than a bright red. The absence of bloody stools does not mean that the intestine is not perforated. Vomiting is common but not in any way distinctive. Pain is often present. A colicky pain, located at first about the umbilical region, is a fairly constant symptom of a lesion of the small intestine (Lagarde). Late cases usually show the signs of advancing peritonitis or, very rarely, of a circumscribed abscess.

The chief external sign is the wound of entrance. A wound of exit may or may not be present. If both are present, some idea may be formed as to what organs are injured, for high-velocity bullets are not easily deflected from their straight path through the body. The escape of fecal matter, omentum, or even a coil of intestine through the wound carries its own message. In wounds of the umbilical region the small intestine is particularly likely to be implicated. It is well to remember that a visible wound of entrance in the abdominal wall itself is not an absolutely necessary accompaniment of a wound of the viscera. The external wound may be in the thorax, the pelvis, the buttock or the scrotum. In such instances, in the absence of a wound of exit, the great difficulty of deciding whether or not the intestine has been injured is manifest.

Prognosis.—The mortality will always be considerable and will vary greatly in different series on account of the necessarily varied character of the injuries and complications, the time elapsed since receival of the injury, the length of transportation and the favorable or unfavorable environment for operation. The skill and experience of the surgeon and his assistants will be another influential factor. So-called "secondary shock," appearing twelve to twenty-four hours after operation, is not infrequent and is usually fatal. Guerry has recently reported a series of operations on 27 cases of penetrating gunshot wounds of the abdomen with 3 deaths, a mortality of slightly over 11 per cent. This is very low. I believe that the average mortality is much higher—25 to 40 per cent.

Treatment.—It must be admitted that statistics may be gathered that will indicate a lower mortality in cases treated expectantly than in those treated operatively. The fairness of these statistics, however, may be questioned. In active military service up to the time of the recent great war the expectant treatment of penetrating wounds of the abdomen was advised and practiced by almost all military surgeons of experience and that view of the matter was not without its supporters (Lagarde) even when applied to civil practice. The very great majority of surgeons, however, agree that in the latter, under the conditions found today in almost every community in the land, exploratory laparotomy should be the rule of treatment in every case of gunshot wound of the abdomen, if it is seen reasonably early and if the case is not evidently moribund. To me this seems to be the only method based

on sound surgical principles. That it has not been practiced on the battle field is not because the principle is incorrect or lacking in any way but because the surrounding conditions limit or render impossible its proper application. I believe that any lowering of our mortality rate in the treatment of abdominal wounds in war will come only through the provision of means for the proper and safe performance of a laparotomy far closer to the firing line than seems possible at present.[1]

Preliminary Treatment.—Refrain from probing, no matter how strong the temptation to probe may be. Apply tincture of iodin; protect the wound or wounds with a sterile or a clean dressing and get the patient to a hospital, if possible. Even in civil life the striking of a balance between the possible dangers of an operation in unsatisfactory surroundings and those of delay and of transportation to a more suitable environment may tax the judgment of the most experienced surgeon. The advantage of hospital over home treatment is so great that even patients with a very considerable degree of shock should be moved to a hospital. Move the patient in a semireclining or sitting position with the knees flexed; give no food, water or medication by mouth; thirst, if bothersome, should be relieved by an injection of tap-water; morphin should be used subcutaneously both for its supportive and its sedative effect; it quiets the patient, "splints" the intestine and lessens shock; great care should be taken to keep the patient warm. Kelling[2] advises also the use of a compression bandage which is to be applied to the abdomen as soon as possible with the object of checking the escape of intestinal contents, of preventing its spread and of localizing the peritonitis. This can be of possible avail only in the first few hours, if at all.

Judgment must be exercised in settling the question of just when to operate. Early operation is certainly indicated but *early* need not necessarily mean *immediate.* If a patient is in first-class or even fair condition, operate as soon as possible. Some of these patients, however, are in marked shock, so marked that the added load of an operation may prove fatal; such a degree of shock is a contra-indication to immediate operation but may not prevent early operation. Much may be gained by a brief delay and relatively nothing lost. A patient who will not react from the shock of his original injury will certainly not withstand the additional shock of operation. Most of the fatalities result from hemorrhage or shock and not from peritonitis. Guerry[3] and others have pointed out that there is in many cases but little escape of intestinal contents for two and possibly three hours and no extensive peritoneal contamination for from four to six hours. This fact offers no reason against an early operation in patients whose condition is good but it may form a very strong argument against too hasty an operation in those who show marked shock. Hemorrhage, or course, demands speedy operation unless there is reasonable certainty that it comes from a solid organ (liver, etc.).

[1] Experience in the recent war has corroborated the truth of this statement.
[2] Centralbl. f. Chir., Leipzig, xlii, No. 15. [3] Ann. Surg., 1915, lxi, No. 6.

One is often embarrassed by the notorious difficulty of distinguishing between the symptoms of shock and those of hemorrhage. No written rule will serve us as a safe guide in this predicament. The individual surgeon must depend upon the judgment, acumen and surgical sense (called instinct), that is the product of only a wide surgical experience. Estimation of the hemoglobin-content of the blood may aid us to come to a conclusion. The bleeding patient is restless and air-hungry; the shocked patient is usually listless and lifeless.

The condition of shock is to be treated in the usual way. Absolute quiet, the application of heat, the "head-low" position (if it seems wise to use it), the judicious use of morphin, the hyperdermic administration of adrenalin (15 m. of the commercial solution), the intravenous or subcutaneous injection of salt solution and the possible employment of transfusion are to be borne in mind. If the patient shows no signs of recuperating at the end of an hour or two, the chances are against his recuperating at all and operation is contra-indicated.[1]

Operative Treatment.—As a preliminary to operation it is advisable to wash out the stomach. The incision, as a rule, should be placed in the median line, beginning about an inch below the ensiform cartilage and extending an inch below the umbilicus.[2] Later this may be lengthened or otherwise modified, if circumstances demand it; do not hesitate even to cut the rectus muscle at right angles, if necessity for such action arises (as in wounds of the spleen, etc.). Knowledge of the line of direction of the bullet may limit our search to one section of the peritoneal cavity and thus in some cases determine the location of the incision. Wherever it be placed, let it be of generous length that a wide exposure may be gained. The viscera will then suffer less operative trauma, the necessary procedures may be applied more easily, control of hemorrhage is more quickly and more certainly secured and much valuable time will be saved. Once the peritoneal cavity is opened, work just as speedily as is consistent with safety and thoroughness. If there is profuse bleeding, first secure and tie the wounded vessels; profuse hemorrhage is likely to arise from the mesentery. Extravasated blood should be removed by sponging.

Unfortunately, multiple perforations are the rule; hence the whole small intestine must be examined systematically. Many operators begin at some easily recognized point as the ileocecal junction but McRae[3] begins anywhere, marking the point of starting by carrying a strand of catgut or bit of gauze tape about the intestine. This, I believe, is a time-saving measure. Complete or even extensive evisceration is almost never necessary and is contra-indicated. Slip the coils of intestine between the fingers rapidly; if a perforation can be closed easily by suture, close it, wash the section of gut with salt solution and return the coil immediately to the peritoneal cavity. Such sections as require more extensive procedures should be lightly clamped above

[1] Goltman: Surg., Gynec. and Obst., 1918, xxvi, No. 2.
[2] Brown, John Young: Ibid., 1914, xviii, No. 6.
[3] Kelly-Noble: Gyn. and Abd. Surg., 1908, ii.

and below the injury, protected by towels and temporarily left outside the peritoneal cavity for subsequent attention; uninjured and repaired sections should be replaced immediately.

It may be laid down as a principle that closure of perforations, when it can be carried out safely, is much to be preferred to resection. Small perforations are easily closed by a purse-string suture of linen or silk; large perforations and linear tears require a linear suture which, when possible, should be applied at right angles to the long axis of the intestine. Lagarde notes that six interrupted sutures to the inch are sufficient. When, as is sometimes necessary, a suture line must be laid in the long axis of the intestine, care must be taken not to encroach too much upon the lumen. It is remarkable how successfully the small intestine will adapt itself to obstructive conditions and overcome them in its own way but it is not safe to diminish its caliber operatively more than one-half. Very large tears and perforations as well as injuries at the mesenteric border are best treated by resection. Lagarde advises that resection should always be done, if the injury at the mesenteric border involves one-half inch or more of the tissues. Any injury that compromises the blood supply should be similarly treated; sections of intestine in which the perforations are very numerous or in such close proximity that obstruction would follow closure should be resected. Occasionally Summers'[1] procedure of invaginating gangrenous gut downward into healthy intestine may be applied to the wounded portion, if it be less than two inches in extent. Most surgeons make successful use of a single row of Connell mattress sutures for joining the intestinal ends after resection. This may or may not be reinforced by interrupted seroserous sutures; one is apt to do too much rather than too little sewing. Personally, if I use the Connell suture, I prefer to use a continuous suture of fine chromic catgut, which may or may not be reinforced by interrupted mattress sutures of linen. I have used with success a single suture of linen after the Connell method, as advised by Willard Bartlett. Each surgeon should use the method that is best in his hands. In mesenteric injuries the lateral method of anastomosis has obvious advantages. The question of method, however, is of secondary importance. In very desperate cases the traumatized portion may be excised and the open ends of the intestine be placed in the abdominal wound pending a more propitious time for further operation.

Thornburg[2] reports a rare case of gunshot wound in the treatment of which a novel and very valuable expedient was successfully used. In addition to other severe intra-abdominal injuries, Thornburg found 35 cm. of ileum completely denuded of its peritoneum and most of its muscular coat; its mesentery had been completely destroyed; no perforation of the lumen could be demonstrated. He did not resect but carefully sutured the omentum around the whole length of denuded intestine (Fig. 1); in other words, he substituted omentum for two bowel-coats and for the mesentery over a length of 35 cm. and the

[1] Jour. Am. Med. Assn., 1908, li, No. 6.
[2] Ann. Surg., 1912, lvi, No. 6.

man recovered. Moschcowitz[1] also relates a remarkable instance of the preservation of the viability of four inches of small gut (devoid of mesentery) which Nature had surrounded by omentum. This expedient may be adopted in instances in which there is doubt as to the viability of a section of the intestine and when resection would tax too greatly the strength of the patient; or a section of doubtful viability may be separated from the rest of the peritoneal cavity by gauze packs and be put into such a position as will allow of its being observed until a decision can be made or the patient's condition is better.

FIG. 1.—Omentum covering denuded intestine.

When shall we operate? Just as soon as the condition of the patient will permit—within six hours after injury, if possible. An operation done within an hour gives a patient 75 per cent. better chance than an operation six hours after injury (McRae). As far as shock is concerned, it will usually respond to treatment promptly, if at all. Delay, as a rule, adds greatly to the danger. Statistics indicate a mortality of 15 per cent. in cases operated upon in the first twelve hours and of 67 per cent. in those operated upon in the third twelve hours (Rodman).

Some surgeons advise against operation, if twelve hours have elapsed since the time of injury. I believe with Guerry that, if operation will offer the patient any chance at all, it should be done regardless of the elapsed time. The condition of the patient and not the number of elapsed hours since injury should settle the question. When the existence of widespread peritonitis is evident, even operation, it must be admitted, offers little hope. Practically the only contra-indication to operation in these late cases is the evident fact that the patient is moribund. Yet operation should not be done, if it will injure or

[1] Ann. Surg., 1913, lvii, 262,

lessen a patient's chances. Lagarde's caution should not be cast aside. "When the patient is doing well," he says, "eighteen to twenty-four hours after the receipt of the injury, operation should be withheld." This will happen in but few cases; nevertheless, the advice is worth bearing in mind. Again the judgment of the individual surgeon must be called into action. Rules cannot be formulated that will meet every contingency.

The Use of Irrigation and Drainage.—The question of irrigation is a much disputed one. If the soiling is pretty well localized, the intestinal contents and inflammatory exudate may be carefully removed with moist wicks and irrigation dispensed with. A Poole tube may be of much use in removing an exudate. Very extensive soiling, however, may demand irrigation and this should be done through a Blake two-way irrigator. In general, avoid irrigation when possible. It is really not often necessary.

John Young Brown, who has had an unusually wide experience in this field, in cases with marked shock starts irrigating the abdominal cavity with a saline just as soon as the peritoneum is incised. A good sized rubber tube, placed in the vesicorectal pouch through a stab wound just above the pubis, allows the fluid to escape. He emphasizes the fact that the irrigation is for stimulation and not for cleansing. In his hands this procedure has been of great use in desperate cases.

I believe strongly in drainage. It should be secured in practically every case by position (Fowler) and by a glass or split rubber tube placed in Douglas' pouch. The question of a small local drain must be settled by the circumstances. If local drainage is deemed expedient, use rubber tissue to protect the drain; never carry a gauze drain down on to a suture line; it renders the occurrence of a fecal fistula practically certain. Counterdrainage also may be necessary.[1]

Postoperative Treatment.—This is important. Give only small quantities of water by mouth for twenty-four to thirty-six hours; then other liquids may be given. For the first twenty-four hours, control pain and peristalsis by morphin. Give tap-water by rectum, if the large bowel is uninjured. Salt solution may be given either subcutaneously or intravenously, if enemata may not be used. Do not continue the Fowler position too long. It is often uncomfortable and in the first eight to ten hours has accomplished all the good that can come from its use. Adrenalin is the best single drug we have for raising blood-pressure and combating shock. Distention, when it appears, may be fairly well controlled by the intramuscular administration of pituitrin (1 c.c. repeated in two hours), by the application of dry heat to the abdomen (electric light bath, etc.), and by the use of the rectal tube or an alum enema. The only sane treatment of vomiting is the withholding of everything by mouth and repeated gastric lavage.

Five per cent. of these cases are said to perish by tetanus. Guerry on the first, fourth and sixth day gives immunizing doses of antitetanic

[1] It is the consensus of opinion now that drainage is advisable only rarely. It is certain that surgeons have been using drainage in abdominal cases too freely.

serum. Guerry has had wide experience and I believe in the wisdom of this procedure.

Stab Wounds.—These are usually less dangerous than gunshot wounds, since the injury is likely to be more localized and multiple injuries of the small gut result only rarely. As with gunshot wounds, an exploratory incision is our only means of estimating correctly the damage done and of applying suitable treatment. Because the injury is better localized, less handling of the viscera is necessary. The principles of treatment differ in no way from those of gunshot wounds.

Injury of the Small Intestine through Blunt Force.—The consideration of such injuries is of great practical significance. The fact that there is usually little and often no external sign of injury and the consequent unwillingness of the physician to advise and of the patient to permit surgical interference until absolutely compelling indications have been exhibited has cost many lives. The high mortality of such injuries even at present almost forces our attention.

In injuries by blunt force, the small intestine again is the most frequently affected viscus. While the movability which its mesentery gives protects it somewhat against injury, yet this very mesentery, carrying as it does the vascular supply of the intestine, is also an added element of danger. The portion most frequently traumatized is the upper jejunum, though the ileum and jejunum as a whole are quite equally affected. The injury is usually single but in as high as 15 per cent. of the cases it is said to be multiple (MacCormac).

It may be the result of a force applied directly or of one acting indirectly. A study of many reported cases indicates the following general classifications:

1. Cases due to a crushing force which catches the intestine between the traumatizing agent and the spinal column or the brim of the pelvis; a perforation of the gut, a tear of the mesentery with injury to the vessels or a separation of the intestine from the mesentery is the result. The majority of cases fall into this class.

2. Cases in which a temporarily isolated loop is actually burst or exploded by a sudden raising of the pressure within the loop.

3. Relatively uncommon cases in which the intestine is torn from its point of fixation. This happens most often near the duodenojejunal angle and occurs in falls from a height, when the patient lands on his feet or on his buttocks. A sudden blow on the back has been known to cause such an injury.

A study of the mechanical principles active in these various classes is interesting but is not relevant here.

The lesions secondary to subcutaneous injury vary greatly in degree. Of the less important and less dangerous only passing notice will be made. Rupture of small vessels in the intestinal or mesenteric walls with the formation of subserous hemorrhages or blood cysts usually of limited extent are of no great clinical interest. The mucous membrane alone may be damaged and an ulceration may follow, which, in healing, may give rise to contraction and to some degree of intestinal obstruc-

tion. Again, the injured bowel may allow the passage of infective bacteria from the lumen and the formation of an adhesive peritonitis may follow (König). These lesser injuries may be the cause of symptoms of peritoneal irritation, etc., which will not appear for several days after the injury.

Barker[1] reports a case of stricture of the intestine, caused by injury to the mucous membrane and consequent contraction of the ulceration, which was operated on seven years after the accident occurred. Periodic attacks of pain and vomiting were the only symptoms.

Symptoms and Diagnosis.—An accurate story of the preliminaries is of peculiar value in this class of cases. A full intestine, for instance, is far more likely to be seriously injured than an empty one; hence, the character of the last meal and the approximate length of time between its ingestion and the accident may furnish an important factor for our consideration. Far more important, however, is the determination of the suddenness of the accident. The protective power of the firmly contracted abdominal muscles is very great—a fact appreciated and utilized by every prize-fighter in the ring. If by the suddenness of an accident the abdominal muscles are caught in a relaxed state, there is but little defence interposed between the viscera and the external force and a severe injury results in almost every instance. The very high mortality following untreated or improperly treated cases of abdominal contusion from pieces of board hurled from circular saws, planing mills, etc., is sufficient proof of this. Even relatively slight trauma applied to the sac of an inguinal or femoral hernia containing intestine is almost certain to cause a perforation.

An estimation of the nature of the force and the direction of its application is also valuable. The passing of a wagon or automobile wheel, for example, over an abdomen is a frequent cause of a tear or separation of the mesentery.

The degree of damage consequent upon these blunt contusions varies greatly. Sometimes only the tissues of the abdominal wall itself are injured; at other times, visceral lesions of varying extent are present. Occasionally a traumatic intestinal paresis may result, there being no demonstrable intestinal lesion. Obviously, means of making correct differentiation between the possible conditions would be most welcome. Unfortunately, however, the early symptoms of a severe injury may differ in no essential way from those of an unimportant injury and we may thus be lulled into a dangerous feeling of security.

Some years ago, when I had to do with the accident service of the Boston City Hospital, I became interested in the subject of abdominal contusions and particularly in that phase of it which had to do with the question of early diagnosis between severe and unimportant injuries. I[2] analyzed the cause and the early symptoms and signs of 20 cases of proved severe intestinal injury caused by blunt force and of an equal number of cases of undoubted simple abdominal contusion from nearly

[1] Lancet, London, 1900, ii, 164.
[2] Boston Med. and Surg. Jour., 1901, cxlv, No. 23.

identical causes. Pain, shock, tenderness, muscular spasm, dulness, vomiting, distention and external signs of violence—the symptoms common to both classes—were carefully studied and several interesting deductions made. In the first place, apparently identical (in so far as we can determine) causes may produce a comparatively insignificant or a very severe injury. It is equally difficult to estimate the amount of force exerted by the acting agent and the degree of resistance or lack of resistance offered by the subject. For instance, in this series were 7 cases caused by being struck in the abdomen by the shaft of a wagon; in 4, intestinal perforation resulted; in 3, injury to the abdominal wall only and, strange to say, in 1 of the latter the force was so great as to produce a true traumatic hernia at the point of impact.

Nothing definite in the way of diagnostic aid was derived from this study. There is no symptom or combination of symptoms that distinguishes the serious from the unimportant injury. We have no certain preoperative means of differentiating between a simple abdominal contusion and one complicated by severe intestinal injury. I believe, however, that observation of the pulse-rate repeated at half-hour intervals may be of some value. It is long since I have had to do with these cases but, were I put in charge of a doubtful early case now, my first care would be to start a regular, frequently repeated, pulse-observation. A steadily rising pulse, after the patient has had an opportunity to become quieted, indicates serious trouble and warrants operation.

Muscular spasm or rigidity is accepted by some surgeons as a distinguishing mark of the more severe injury but in my experience it is not a safe guide. In my series it was frequently present in both classes. Absolute rigidity of the abdominal wall was found in 2 cases of simple contusion, when the patient entered the accident ward. Even the retracted belly, usually considered pathognomonic of a general peritonitis, appeared on the second day in a case of contusion, continued for about twenty-four hours and then disappeared. Besides, the difficulty of distinguishing between voluntary and involuntary spasm is sometimes very marked. So distinguished an authority as W. J. Mayo believes that the *continuation* of muscular rigidity is sufficient to warrant operation in a doubtful case.

De Quervain[1] mentions as an important early sign of intestinal perforation the presence of a circumscribed area of tympany, demonstrable by percussion in the upper portion of the abdomen with the patient in the supine position and shifting to the left hypochondrium with the patient in the right lateral position. I have had no opportunity of testing the value of this sign but it is worthy of mention in passing. I regard it as difficult of demonstration. The same may be said of Makins'[2] fixed area of "deficiency of resonance." The disappearance of liver dulness is of no great diagnostic significance. Rapidly developing metorism after abdominal contusion is due to a reflex paresis of intestine and is not necessarily a sign of serious visceral injury.

[1] Clinical Surgery Diagnoses, 1917, Wm. Wood & Co., New York.
[2] Ann. Surg., 1899, xxx, No. 2.

Even in severe injuries the symptom picture is varying and uncertain. Hemorrhage may and often does add to the confusion. Watchful waiting may occasionally aid us in coming to a decision but long waiting spells death. The truth of the matter is that the only certain means of differentiating between a simple contusion and one complicated by intestinal injury is exploratory laparotomy. This not only affords accuracy in estimating the character and extent of the lesion but it furnishes the only means of adequate treatment. The fact that an unnecessary laparotomy may occasionally be done is no argument against the worth of the procedure. Against that fact may be placed the far more weighty one that many lives will be saved that otherwise would be sacrificed.

Prognosis.—Expectant treatment means practically 100 per cent. mortality. Operation in the first five or six hours will give a relatively low mortality. The mortality then will be that of the lesion and not that of delay.

Lund, Nichols and Bottomley[1] report 6 cases in which operation was done with 4 recoveries, the deaths occurring in cases in which operation was done after many hours had elapsed.

Siegel[2] has collected 376 cases of rupture of the intestine which have been submitted to operation. The mortality was 51.6 per cent. Cases operated upon in the first four hours showed a mortality of 15.2 per cent.; within five to eight hours, 44.4 per cent.; within nine to twelve hours, 63.6 per cent.; after twelve hours, 70 per cent. These figures speak for themselves.

Treatment.—Early laparotomy is the only sane treatment. It should be done, if possible, within five or six hours. The passing of every hour beyond that time decreases in a marked degree the patient's chances for life. The principles of procedure, once the abdomen has been opened, do not differ materially from those enumerated under the treatment of gunshot wounds. Some injuries can be repaired by simple suture; others require resection. Which procedure is to be adopted must be decided by the surgeon in the individual case.

The rent in the intestine is often large in these cases and the escape of fecal contents rapid and relatively profuse. In such cases Nature has no time to wall off and thorough flushing of the peritoneal cavity should figure in the operative measures.[3]

DISEASES OF THE JEJUNO-ILEUM.

Peptic Ulcer.—Though peptic ulcer of the jejunum was first definitely called to the attention of the medical profession by Braun as recently as 1899, it has rapidly taken an important place in surgical literature. Undoubtedly, our increasing knowledge of it is due to its intimate relation to the operation of gastro-enterostomy. Under normal

[1] Boston Med. and Surg. Jour., 1902, cxlvii, No. 22.
[2] Moynihan's Abdominal Operations, Philadelphia and London, 1914, ii, 83.
[3] Davis: Boston Med. and Surg. Jour., 1915, clxxii, No. 5.

anatomical conditions, primary ulcer of the jejunum is rarely seen but, under the changed conditions brought about by a gastro-enterostomy, jejunal and gastro-jejunal ulcers are of sufficient frequency and seriousness to merit our notice.

The ulcer may be located on the line of the anastomosis (gastro-jejunal ulcer) or in the jejunum itself in the neighborhood of the anastomosis (jejunal ulcer). It follows gastro-enterostomy for benign conditions at the pylorus or in the duodenum; only one undoubted example after a gastro-enterostomy for malignant disease is known. In other words, it is a complication of operation for stomach conditions in which the acid content is high. Yet it may be said, I believe, that while hyperacidity and a benign stenosis may figure somewhat as etiologic factors, nevertheless the doing of gastro-enterostomy for insufficient or no reasons and a faulty technic which invites infection and prolongs its effects are the important exciting causes of gastro-jejunal ulcer. On the other hand, true jejunal ulcers are the result of alterations in the normal physiological intestinal conditions (W. J. Mayo).

At the Mayo Clinic only the gastro-jejunal variety has been seen and an evident exciting cause has almost always been found in the shape of a long-retained linen suture or of an infected hematoma. My personal experience has been limited to two cases in both of which the end of a linen suture projecting into the lumen was the undoubted cause. Both were of gastro-jejunal variety.

While the ulcer may follow any form of gastro-jejunostomy—the anterior, the posterior, the Y-variety of Roux or one in combination with an entero-anastomosis—yet it is far less frequent and may be regarded as truly uncommon after the posterior form. It is usually single, occasionally multiple, and is seen most often in males (84 per cent. of the cases) and in middle life. It follows the primary operation after intervals varying from a few days to seven years but it is likely to appear within the first six months, if at all. It is worthy of note that there is no record of a case subsequent to gastro-duodenostomy.

Of 146 cases collected by Schwarz,[1] only 39 were of the gastro-jejunal variety. These figures, I believe, do not agree with the experience of American surgeons.

These ulcers have a strong tendency to perforate and perforation may take place directly into the peritoneal cavity with a resultant acute peritonitis. Occasionally without gross signs of perforation of the ulcer a subphrenic abscess may follow. The subacute form of perforation is the more common and it may involve the anterior abdominal wall (generally the upper portion of the left rectus muscle), the chest wall, the mesentery, the transverse colon or the liver. Penetration into the chest-wall, the mesentery or liver is rare. Subacute perforation into the rectus muscle is the most common form. Perforation into the colon is next in order of frequency. It must not be forgotten, however, that the ulcer may exist with little or no tendency to perforation.

[1] Arch. f. klin. Chir., Berlin, 1914, liv, 694–732.

Symptoms and Diagnosis.—In the acute perforating cases, the ulcer, as a rule, develops rapidly (within a few days or weeks) and perforates in a short time. There may be few or no prodromal symptoms. Hence, if at any time, short or long, after a gastro-enterostomy, symptoms of acute perforative peritonitis appear, our first thought must be of a perforated jejunal ulcer.

The early symptoms of the most common form, *i. e.*, the subacute or chronic perforation into the sheath of the rectus muscle, may be trivial or striking; they may be no more than a somewhat bothersome distress appearing after a meal and relieved by alkalies or they may be just as severe as those of the original trouble and lead to great distress and marked vomiting. In due time, a tender, gradually increasing, immovable induration develops in the epigastric region, usually in the left rectus muscle between the umbilicus and the xiphoid cartilage and it is only necessary to recollect the possibility of peptic ulcer following gastro-enterostomy that a definite and correct diagnosis may be made. This abdominal type is the most frequent and the worst form; unfortunately it shows an inclination to recurrence.

The symptoms preceding perforation into the colon are not characteristic. Once the perforation has taken place, however, the diarrhea, the wasting of the patient because of lack of nutrition and, most certain of all, the vomiting of the contents of the colon make a diagnosis possible.

The fact that a perforating jejunal ulcer may exist as a simple ulcer sometime before it perforates and that many jejunal ulcers are non-perforative must not be disregarded. The symptoms of one are not to be distinguished primarily from those of the other. In general, it may be said that the subjective symptoms of uncomplicated jejunal ulcer are those of the original gastric or duodenal ulcer for which the gastro-enterostomy was done. In my experience, the seat of the pain, etc., has been more to the left but that may not be invariably so. The pain or distress coming on after meals and the relief obtained by diet and alkalies, the vomiting of blood, the presence of blood in the stools may all be noted. On the other hand, a rather mild distress may be the only complaint. Occasionally there may be sufficient induration about the ulcer to block the opening and cause symptoms of gastric stasis.

Carmen and Balfour[1] from a study of eleven cases at the Mayo Clinic conclude that there are no pathognomonic symptoms of these secondary ulcers. The matter may be summed up by saying that after gastro-enterostomy for benign conditions of the stomach or duodenum the constant appearance of any of the original symptoms forces one to assume the possibility of recurrence of the original trouble or the formation of an ulcer on the anastomotic line or in the jejunum close to it. The differentiation between the two possibilities is clinically unimportant.

The Roentgen findings may be of aid in diagnosis (Carman and

[1] Jour. Am. Med. Assn., 1915, lxv, No. 3.

Balfour). In one group of cases, they show "retention from the six-hour meal, large size of stomach, lessened mobility of stomach, exaggerated peristalsis and spasticity;" in another group, "deformity of contour about the stomach, deficient patency of the stroma, local irregularity of the jejunal contour and dilatation of the duodenum." It is needless to say that only the most expert roentgenologic work is of value in the diagnosis of these complicated cases.

Prognosis.—The mortality is high. Schwarz's collected cases showed a mortality of 24 per cent. and about 21 per cent. of the survivors were either uncured or only partially relieved.

Of the 25 cases of the acute perforating variety, 18 died. Of the 9 cases operated on, 7 were saved.

Of the 51 cases in which perforation into the abdominal wall took place, there were 7 deaths. Seventeen cases were not cured or recurred. This is probably too low an estimate of the recurrences since many cases were reported as cured only a short time after operation. Nine cases were operated upon twice (not including the gastro-enterostomy), 4 cases, three times and 1 case, four times.

Perforation into the colon was found in 19 cases and the mortality was about 30 per cent.

In the 39 gastro-jejunal ulcers, the mortality was less—about 5 per cent.

Treatment.—The most important phase is the preventive. Gastro-enterostomy should not be done save in the presence of clearly demonstrable indications for it. When it is indicated, either gastro-duodenostomy or the posterior no-loop variety of gastro-jejunostomy should be chosen; if the latter is decided on, its technic should be carried through very carefully. The retaining clamps should not be applied too tightly lest permanent damage to the bloodvessels or to the serous surfaces result. The seroserous sutures are to be regarded as merely supportive of the through-and-through, should not be too numerous and should be interrupted. Fine silk or linen is the material of choice for these. Fine absorbable material (chromic catgut No. 0) should be used for the through-and-through (the hemostatic) sutures; they should be carefully and closely placed and should be applied firmly but not too tightly.

Possible septic intra-abdominal causes (appendicitis, cholecystitis, salpingitis, etc.), of the gastric or duodenal ulcer should be sought for and, if present, removed.

After the primary operation the anti-ulcer diet should be continued for a considerable time and alkalies should be administered by mouth. The use of alcoholic and very hot drinks should be prohibited. The teeth, the mouth, the throat, the nose, the sinuses, etc., should be examined and, if diseased, should have suitable treatment.

By some surgeons, gastro-duodenostomy has been advised as a substitute for gastro-jejunostomy. However, in my opinion, peptic jejunal ulcers are so uncommon after a properly indicated, well-done, gastro-jejunostomy that the substitution for it of any other operation is not demanded at present.

On the appearance of the symptoms the resumption of a strict diet and the exhibition of alkalies in sufficient quantities may cause a recession of the symptoms and even an occasional cure. Certainly, medical and dietetic measures should be tried first.

Operative Treatment.—This may offer numerous and great difficulties, particularly in the subacute and chronic perforating form.

In the acute perforating variety immediate laparotomy with closure or excision of the perforation is indicated. This is not a common variety.

In perforation into the colon, the attachment between the two viscera must be severed and the opening in each closed. It may be necessary to resect a portion of the colon. A new anastomosis must be made.

In uncomplicated jejunal or gastro-jejunal ulcer, a transgastric or transjejunal excision of the ulcer may be done; or the gastro-enterostomy may be undone and, after excision of the ulcer, resutured; or the openings in the stomach and jejunum may be closed and an anastomosis laid in a new position in the stomach; with some jejunal ulcers resection and end-to-end anastomosis may be possible.

That variety of ulcer which perforates subacutely into the anterior abdominal wall presents the greatest operative difficulties. No rules of procedure can be set down. I believe that the most radical and the safest procedure is to separate the adhesions—always a difficult, trying job—undo the gastro-jejunostomy, close both the stomach and the intestine and make a new anastomosis; or, what is sometimes better, do a gastro-duodenostomy. Occasionally it may be possible to excise the ulcer and to do a plastic operation on the anastomosis. Mayo considers this the operation of choice.

None of these procedures may be possible. It may be necessary to undo the anastomosis, excise the ulcer, close the end of the distal loop of the divided small intestine, do a lateral anastomosis between the distal loop and the stomach and implant the proximal loop into the distal by an end-to-side anastomosis. Usually, after freeing the adhesions, the undoing of the gastro-jejunostomy is made possible without soiling by putting a clamp on the stomach and another on the loop of small intestine. This, however, is not an essential step since the danger of contamination is only very small in any event.

Sometimes, whatever be the variety of the lesion, when the primary operation was evidently done for no adequate reason, the making of a new anastomosis may be dispensed with, provided that the pylorus is still functionating.

The tendency to recurrence seen in this variety of peptic ulcer may lead to the doing of two to four operations, each of increasing difficulty. In fact, a radical curative operation may be impossible and a jejunostomy may be our only resource.

Typhoid Ulcer of the Small Intestine.—While typhoid ulcerations of the small intestine are usually of interest only to the internist, yet the fact that, on an average, 3 per cent. of them perforate brings that

portion, at least, decidedly within the limits of surgical endeavor. While perforation may take place anywhere in the jejuno-ileum, it has been within twelve inches of the ileocecal valve in about 75 per cent. of the recorded cases and over three feet away from it in only 2 per cent. In approximately 87 per cent., the perforation is single. It is far more common in young men (under forty). It is not infrequent in infants and young children. Its occurrence bears no relation to the severity of the disease, perforation taking place in both the mild and the severe types. It may happen any time after the first few days of illness, but over 50 per cent. of the perforations come in the second and third week; it is rare in the first week and not uncommon after the third week; occasional cases during the convalescent period have been reported. The perforation is usually located upon the free border of the gut opposite the mesentery and varies in size from that of the head of an ordinary pin to that of a silver quarter.

Symptoms and Diagnosis.—At the outset, it must be noted that the co-existing systemic disease with its abdominal manifestations, its apathy and its decreased sensibility may add very materially to the difficulty of diagnosis. A perfectly typical picture is uncommon. The most prominent symptoms of perforation are the pain, the change in facial expression, the rise in pulse-rate, the localized tenderness and the muscular rigidity. Too much stress should not be placed on a change in temperature and none at all on the disappearance of liver dulness which is unreliable as a diagnostic sign here as well as in intestinal perforations in other places and from other causes. It is unsafe and unnecessary to postpone operation until one is absolutely sure that perforation has taken place; a strong, well-supported suspicion is a sufficient warrant for operation.

Pain is usually the first symptom and its degree varies with the apathy and dulness of the patient and the amount and suddenness of the fecal extravasation. The classical sharp, sudden, violent pain of perforation under other conditions may be entirely absent. It is usually referred to the lower abdomen in the midline or to the right of it. It is continuous and severe, when the extravasation has been sudden and abundant. Its absence or its lack of severity adds, of course, to the difficulty of a diagnosis.

The change in facial expression is a very important sign. Armstrong calls emphatic attention to its diagnostic worth. The change is in the direction of the well-known peritonitic facies and suggests the impending or recent catastrophe. The general appearance of the patient becomes alarming.

A sudden rise in the pulse-rate is always present. Repeated careful observations of the pulse are of far more diagnostic value than records of the temperature. As far as the latter is concerned, there is a wide divergence of opinion as to whether a primary rise or fall occurs. I believe that observation of its course is of entirely secondary importance in comparison with that of other symptoms. The respiratory rate usually increases with the pulse-rate. Neither vomiting nor chills

nor sweating, which not infrequently occur, are important as early distinguishing signs. Muscular rigidity and tenderness are important, should be carefully sought for and their degree estimated; both are usually most marked in the lower abdomen to the right of the umbilicus; the presence of tympanites and the mental dulness or the delirium of the patient may combine to make them less manifest. A digital examination by rectum should always be made in search for an area of marked tenderness.

The results of the blood count should be regarded only as a diagnostic aid and as confirmatory or non-confirmatory of an opinion based on other evidence. The relative increase in the polynuclear cells is the important feature. While leukocytosis is a very frequent accompaniment of typhoid perforation, its absence does not exclude perforation and is really of no great diagnostic value (Gibbon). A leukocytosis may not develop for eight to twelve hours after perforation has taken place.

"Preperforative" Signs.—Hawkes[1] considers the mental picture usually engendered by the word "perforation" as unfortunate, since he regards perforation as the chance termination of an inflammatory condition which may be recognized long before it reaches the stage of perforation. When a typhoid ulcer distinctly invades the muscular coat of the bowel and thus threatens to perforate, there is almost always an accompanying peritonitis, the early stages of which are recognizable in practically every case by muscular rigidity, tenderness and pain and sometimes by muscular rigidity and tenderness alone. It is the detection of the first appearance of this muscular rigidity that is important in establishing the diagnosis of beginning peritonitis—preperforative peritonitis. By "muscular rigidity" is not meant the grossly evident degree seen in the board-like abdomen but "the lighter shades of muscle contraction and to elicit these the patient must be in a comfortable position, with the mouth open and the muscles relaxed, in a warm room and with an empty bladder. The examiner should then try to get the rigidity with a series of short, but very delicate pushes with the finger tips. It is the recti and the lateral abdominal muscles that should be tested with special care, the right side receiving the first attention. Comparison should be made with the left side. Hawkes makes the point that pain, which is often mentioned as a prominent symptom, does not precede but follows the peritonitis and that a recognizable amount of muscular rigidity and tenderness is often present earlier than the pain. I have not had an opportunity of testing the value of this method of diagnosis of preperforative conditions, but to my mind it brings us on very dangerous ground. The slight degree of rigidity and tenderness must be difficult to elicit even in the average typhoid case and practically impossible in the delirious, the toxemic and the comatose cases. With only that for an operative indication, there would surely follow a marked increase in the number of explora-

[1] Ann. Surg., 1911, liii, No. 5.

tory laparotomies and I cannot feel that in patients in the middle and later weeks of typhoid a slight degree of muscular rigidity and tenderness offers sufficient ground for exploration. There is little, if anything, to be gained in this way over a prompt diagnosis after perforation. The decision, even then, may be doubtful but exploration is more justifiable under such conditions.

There is, however, a very valuable and wholly practical suggestion in Hawkes' paper. In all typhoid cases, a daily routine examination of the abdomen of patients in the second, third and fourth weeks should be made by the physician in charge of the case and in hospitals the house staff should make even more frequent examinations. House-physicians and nurses should be urged to keep these patients under constant observation, both day and night, that the slightest change in appearance and the first complaint of pain may not only be noted but be reported to the visiting physician. Early surgical consultation should be sought and it is not a bad plan for the medical and surgical staff to make frequent joint visits to the typhoid ward. Gibbon makes the very pertinent suggestion that conditional consent for operation should be obtained in every case of typhoid fever so that valuable time need not be wasted, if perforation should occur.

I have considered only the early signs and symptoms. The late manifestations are those of a general peritonitis; when these appear, successful treatment is out of the question.

Differential Diagnosis.—*Appendicitis.*—Peritonitis from a perforation and one resulting from advancing appendicitis give rise to clinically similar symptoms and no particular advantage is to be had from a diagnosis between the two conditions. Both require operation; the onset of appendicitis is less acute, as a rule.

Cholecystitis.—Acute inflammation of the gall-bladder occurs occasionally in the course of a typhoid. The pain, muscular rigidity and tenderness are usually in the upper right quadrant and practically only in cases with the gall-bladder and liver situated at a considerably lower level than usual would there arise great difficulty in differentiating between the conditions; operation then offers the only means of definite, early diagnosis.

Pneumonia and Pleurisy.—These, too, are occasional accompaniments of typhoid. A careful auscultatory examination must be made and it is to be remembered that diminished breathing may be the only early sign of a lung complication. Keeping in mind the fact that lung conditions, particularly in children, may simulate abdominal conditions usually suffices to make the observer wary and to initiate the careful examination of both localities that is necessary for diagnosis.

Suppurating Mesenteric Glands.—A differential diagnosis is not possible. The result of the rupture of a mesenteric gland is peritonitis and that, if the condition of the patient is not too bad, requires operation.

Acute Dilatation of the Stomach.—This is not frequent in typhoid. The characteristic vomiting seen in this condition and the passing of a stomach tube, if the condition is suspected, will clear up existing doubt.

Iliac and Femoral Thrombosis.—The symptoms of collapse are usually absent; no sudden change is noted; the symptoms are not so violent or alarming as those of perforation.

Hemorrhage.—This is not infrequent in typhoid. The symptoms of collapse may be present in either perforation or in hemorrhage but in hemorrhage the blood usually appears by rectum within two hours. The pain, tenderness and muscular rigidity are much less marked in hemorrhage. Rarely the two conditions co-exist; then operation is demanded irrespective of the hemorrhage. A constantly decreasing hemoglobin-index means hemorrhage.

Prognosis.—The condition is a desperate one. Without operation an occasional case may recover, when the perforation is very small and the escape of fecal contents and consequent peritonitis is limited by adhesion-formation, but this occurrence is so rare as to be negligible. Even with operation, the mortality is about 75 per cent. The most important element in prognosis is the timeliness of the operation. Not all deaths are due to the operation; many are due to the disease itself and its complications.

Treatment.—Operation holds out the only hope. Local anesthesia should be used, if possible; however, as may be imagined, the successful use of local anesthesia is not always possible; it may be supplemented by giving a few breaths of ether or ether may be substituted for it entirely; in either event, *very little anesthetic* should be given. If general anesthesia is indicated, ether is preferable to chloroform because of the stimulating effects of the former. Ether, however, adds to the danger of occurrence of postoperative pulmonary complications, which are common.

The operation should be done promptly, if at all. Quick work is necessary. The perforation should be closed by suture, if closure can be made with reasonable ease. If the hole is too large or if the sutures cannot be securely placed, the perforation may be brought up into the wound and held there by a few stitches. This may be the only procedure practicable in some cases. If on opening the abdomen the perforated loop does not appear in the incision (median or right lateral) or is not easily found, the cecum must be identified and a rapid examination made of the lower three or four feet of the ileum. The operation to be effective must be simple and rapid. Nothing is to be gained by delay. Salt solution in limited quantity should be given before or during operation. Be careful not to overload the circulation with too much fluid and thus add to the work of an already embarrassed heart.

Perforation of Ileum by Foreign Bodies.—It is to be remembered that the lower ileum may be perforated by foreign bodies which have been swallowed, such as pieces of bone, toothpicks, pins, etc. The resultant reaction, which is usually local may simulate an acute appendicitis. The possibility of such occurrences should be kept in mind in cases with signs and symptoms simulating an acute appendicitis in which sufficient cause is not to be found in the appendix or in a Meckel's diverticulum.

Other Ulcerative Processes in the Jejuno-ileum.

Uremic Ulcers.—Uremic ulcers are sometimes found in the lower ileum especially with chronic interstitial nephritis and they occasionally perforate.[1]

Catarrhal and follicular ulcers, the ulcerative lesions found in the small intestine in dysentery, diphtheria, erysipelas and other septic processes and those accompanying such constitutional diseases as leukemia and scurvy are of no surgical interest and are only mentioned in passing. Embolic and thrombotic processes which occur in the small intestinal vessels and lead to ulcerative formation are of no particular surgical concern.

Tuberculosis of the Small Intestine.—Surgically considered, this exists in two forms: (1) ulcerative and (2) the hyperplastic. Neither form is of particular interest to the surgeon except through its sequelæ.

The ulcerative form is more common in the lower ileum and may lead to either perforation or to stenosis. Perforation is rare because of the thickening of the peritoneal coat which usually accompanies the ulceration and of the consequent adhesion-formation. Perforation, when it occurs, may take place into (*a*) the general peritoneal cavity and cause a general peritonitis; this is very uncommon; I have seen and operated upon one fatal case (Carney Hospital Surg. Rec., Case No. 3458); (*b*) into an area circumscribed by adhesions; as a result, a tumor will form which will open spontaneously or through operation; a fecal fistula results in either case; (*c*) into a neighboring coil of intestine, into the bladder or into the uterus.

The spread of the tuberculous intestinal process is along the lymphatics in the submucous tissue and consequently the longest diameter of the ulcer is at right angles to the long axis of the intestine. The tendency of the ulcer is to partially organize; thus it frequently causes an intestinal stenosis; in fact, tuberculosis is the most common cause of stenosis of the small intestine.

The hyperplastic form leads to intestinal stenosis through thickening of the intestinal wall.

Symptoms and Diagnosis.—There is nothing characteristic in the symptoms of an uncomplicated tuberculous ulcer of the intestine. They may be entirely absent. An obstinate diarrhea, the movements being fluid and unformed, is the most common symptom but an exact diagnosis is seldom possible, since it is difficult to demonstrate the presence of the tubercle bacillus in the stools. Even at operation, a tuberculous process may be mistaken for a carcinomatous one or *vice versa*. Diagnosis may be possible only after a microscopic examination of the specimen.

A tuberculous process which includes both the cecum and the ileum has symptoms entirely similar to malignant or inflammatory or actinomycotic disease of the same region. Alternating diarrhea and constipation, blood and slime in the stools and, with the lapse of time, the

[1] Thierauch: Arb. auf dem Gebiete der Path. Anat. und Bak., Tübingen, 1914, viii, 2.

appearance of a hard, nodular, immovable tumor and attacks of colic and constipation are common to all forms. The diagnosis may be made through consideration of coexisting signs and conditions, age, general state, examination of the stools, etc.

A history of former tuberculosis or the existence of tuberculous foci elsewhere in the body are important diagnostic factors. The comparative youth of the patients, the slow onset of the disease, the history of remissions and of occasional periods of improvement are evidence in favor of a tuberculous process and against a malignant one.

The symptoms of perforation are characteristic in no way. If the perforation takes place into the free peritoneal cavity (rare), the symptoms of general peritonitis will supervene; if into a localized, protected area (more common), an abscess forms which after some time may usually be felt as a tumor; if into the bladder, by the appearance of fecal contents and gas in the urine, the symptoms of cystitis, etc.

The symptoms of stenosis are those of chronic obstruction and will be considered later.

The diagnosis of tuberculosis of the intestine based upon a positive von Pirquet test is not tenable according to J. B. Murphy, who says that most adults are likely to give a positive von Pirquet without having any signs of active tuberculosis.

Treatment.—Perforation into the free peritoneal cavity demands immediate laparotomy and, if possible, closure of the perforation. What to do in case an ulcer perforates into a closed cavity or into such an organ as the bladder is a grave question. Attempts to close the fistula often result in failure for reasons which will be noted later. In tuberculous enterovesical fistulæ, the results are unsatisfactory. The ideal treatment, when it can be carried out, is resection and closure. The matter will be discussed later (see p. 82).

Unilateral exclusion of the intestinal loop in question has not been successful as a method of treatment. Bilateral exclusion is worth trying in case excision is impossible or fails.

The ideal treatment of stenosis is excision of the point of stenosis with a following or end-to-end lateral anastomosis. The path, however, is beset with difficulties. First of all, the stenosis is usually multiple, the intestinal wall is often infiltrated over a great length and adhesion-formation is usually very widespread (J. B. Murphy). Again, the condition is frequently complicated by the presence of softened, suppurating glands. Furthermore, if resection is attempted, one must cut through peritoneum free from tuberculosis and practically free from infiltration and adhesions; otherwise, the suture line will not hold and a most obstinate fistula will result.

If there are multiple strictures non-adherent or not too adherent to admit of separation, with considerable lengths of healthy bowel between, multiple resections should be done. If there is an adherent, intricate mass of diseased intestine and glands, the surgeon must decide whether the mass can be isolated or not. If isolation is possible, identify a free, healthy, proximal coil and a similar distal one, cut across the lumen well away from the mass and do an end-to-end or a

lateral anastomosis; the mass itself may then be removed. The presence of infected glands in the mesentery may make the resection of a considerable length of intestine necessary and this possibility must be weighed carefully in deciding for or against the attempt at radical removal. If the glandular involvement is too widespread or if the adherent mass cannot be isolated, then a lateral anastomosis should be done between a healthy distal and proximal coil; this may be a simple short-circuiting operation or the intestine may be cut across and the cut ends of the portion forming the mass may be left open to drain on the surface; or they may be closed and returned to the peritoneal cavity. In either event, one acts with the hope that Nature under more propitious resultant conditions will isolate and atrophy the mass (J. B. Murphy).

In very complicated cases, J. B. Murphy advises the intelligent use of Koch's old tuberculin, not with the idea that it cures intestinal tuberculosis but that it stimulates the reparative process and aids Nature in cicatrizing the lesion.

Any method of treatment must, of course, be combined with hygienic measures (good air, nutritious diet, etc.); in fact, these may well precede any attempt at operative treatment, when the indication for operation is not pressing.

Syphilitic Ulcers.—Syphilitic ulcers of the small intestine may result from the breaking down of gummata and are usually found in the ileum. However, syphilitic stenosis in the jejunum is known.[1] Perforation is rare; stenosis of the intestine and chronic obstruction are the resultant phases that may bring the patient to surgical notice. The symptoms are not characteristic and the diagnosis must be made by finding elsewhere associated signs and symptoms of syphilis, by the Wassermann test applied to the blood or to the spinal fluid and by the therapeutic test. The surgical treatment is directed to the relief of the chronic obstruction. General therapeutic measures should not be neglected.

"Strangulation" Ulcer.—An ulcer of the mucous layer may follow the undue or long-continued confinement of a loop of small intestine in a hernial sac. It may give no immediate sign of its presence but its healing and contraction may lead to a later stenosis and obstruction.

Actinomycosis.—Actinomycosis affects the small intestine so rarely that consideration of it here is quite unnecessary. When the terminal ileum is affected, it is practically always in conjunction with associated disease of the cæum—ileocecal actinomycosis.

TUMORS OF THE SMALL INTESTINE.

Morbid growths of any kind are relatively uncommon in the small intestine. Malignant tumors are rare. Only about 5 per cent. of intestinal cancer is found in the small intestine and it is more frequent in

[1] Schmilinsky: Mitt. a. d. Grenzgb. d. Med. u. Chir., 1910, xxii, 390–401.

the duodenum than in the jejuno-ileum. Its earlier embryological development and the fact that its contents are liquid in consistency and alkaline in reaction combine to make the small intestine a far less frequent habitat of cancer than the large intestine with its acid, more or less solid content.

Benign Tumors.

The principal benign tumors are adenoma (the most frequent), lipoma (seen only in adults), fibroma and myoma. Many are pedunculated; some sessile; some are submucous and others, subserous, the latter being less important clinically.

Symptoms and Diagnosis.—The significance of benign tumors depends less upon themselves than it does upon their localization and size. Many of them give no sign whatever of their presence and are found only at autopsy. Only rarely does a benign tumor become of sufficient size to be palpated. It usually declares itself through (*a*) causing an intussusception (this is the most common result); or (*b*) by reaching sufficient size to block the lumen either from within (obturation) or, originating from the serous or subserous coat, from without by kinking the intestine.

The *symptoms* both of the invagination and the obturation may be of the acute or chronic variety and will be considered later. Preobstructive symptoms are so indefinite and meaningless as to be worthy of no attention. Of course, malignant degeneration, if it occurs, may cause its own peculiar signs but only a very few benign tumors have a tendency to degenerate and become malignant.

Certain individuals, usually young, seem to have a predisposition to the formation of polypus tumors (König). The symptoms are diarrhea, abdominal pain and the passage of blood and mucus. The prognosis is not good; the subjects usually die of hemorrhage or of cancer. I have often wondered if multiple, small, adenomata are not the cause of many of the cases of intestinal bleeding in adults for which no source can be demonstrated even at operation.

Treatment.—The treatment is really that of the resultant condition, *i. e.*, the treatment of the invagination or the obturation. A practical point worthy of mention is that in every case of reducible intussusception, especially in an adult, search should always be made for a tumor of the intestine as a possible cause.

Occasionally, a pedunculated tumor will slough off and be passed spontaneously per rectum.

Malignant Tumors.

Cancer, as has already been noted, is rare. Sarcoma, though actually uncommon is, nevertheless, relatively frequent in the small intestine

Cancer.—It is almost without exception primary and its favorite location in the jejuno-ileum is the lower ileum and upper jejunum.

Originating in the intestinal glands, it appears almost always as a cylinder-celled adenocarcinoma and may be simple, medullary or scirrhus. It is seen most frequently in men and after the age of forty, but one-sixth of the cases occur between thirty and forty and one-seventh under thirty (Maydl). It is only very rarely multiple, though Bailey[1] reports such a case, in which there were two distinct malignant tumors in the jejunum. Bland Sutton calls attention to three distinct types (1), most common, the stenosing type, (2), uncommon, which shows the growth sprouting like a cauliflower into the lumen and (3), a massive form which envelops the intestine with a hard collar of new growth.

Symptoms.—Pain is the most constant symptom and, if persistent, severe and unrelieved by rest and starvation, is surely the most reliable sign. It is usually colicky and not particularly well localized. Constipation is customarily a marked sign and often in the early course of the trouble alternates with diarrhea. The symptoms are really those of an indefinite, wasting, intestinal disturbance to which are gradually added definite signs of intestinal obstruction; the obstructive signs are not so frequent or so well marked as in cancer of the large bowel because of the liquid contents of the small intestine. Occult blood is usually present in the stools and visible blood occasionally. Cachexia and anemia appear relatively early. As a rule, loss of weight is steady. Early symptoms may be entirely lacking and the first sign of trouble may come from the appearance of symptoms of a partial or complete intestinal obstruction.

A palpable tumor is sometimes present but is uncommon and appears too late to be of aid in early diagnosis; when a tumor can be palpated, a curative operation is usually out of the question. It is almost always in the lower abdomen and is characterized by its great movability, unless it has become closely adherent to a fixed organ. Cancerous tumors of the jejunum are too deeply placed to be palpated except in rare instances.

A definite diagnosis is usually quite impossible except through roentgenologic findings or through an exploratory laparotomy. The Wassermann or the therapeutic tests may be used for the purpose of excluding syphilitic tumors. There are really no clinical signs or symptoms which lead to accurate localization of the growth.

I purposely avoid more than a mention of the Abderhalden ferment diagnosis, though a very high percentage of successful diagnoses, in suspected cases of cancer has been reported. The test is highly technical and should be undertaken only by men especially trained in the technic. Errors creep in so easily that a negative report from any but an experienced observer is of no value.

Prognosis.—The immediate prognosis is fairly good. The remote prognosis is very unfavorable. Many cases get temporary relief through operation but permanent recovery is rare. Our only hope of

[1] Jour. Missouri Med. Assn., 1912–1913, lx, 53–57.

bettering prognosis is through early operation. Our only present means of making even an approximately correct early diagnosis are roentgenology and exploratory laparotomy. I believe that every patient who has indefinite symptoms of intestinal disturbance with a steady loss of weight and strength should be advised to submit to an exploratory laparotomy, even if the *x*-ray does not show a definite lesion. A skiagraphic plate, even when developed and interpreted by the great experts in that field, is sometimes misleading; in the hands of the average roentgenologist in doubtful cases, very frequently so.

Treatment.—The ideal treatment is resection of the diseased portion with all involved glands and adherent omentum. The implication of neighboring coils means multiple resection.

Conditions, however, do not always permit the performance of the ideal operation. A lateral anastomosis between a coil proximal and another distal to the growth should be done under such circumstances. Resection may be thought of later.

Glandular involvement is common; metastasis in other organs is not common; when it has taken place, radical operation is, of course, not indicated. The presence of ascites also contra-indicates radical operation. In either case, there is no reason why a side-tracking operation may not be done for the relief of obstructive symptoms.

Sarcoma.—Sarcoma is more likely to attack the small than the large bowel. Sixty-five per cent. of intestinal sarcomata are found in the small intestine. Like cancer, its favorite seats are the lower ileum and upper jejunum. It is more frequent in men than in women. While it, too, occurs most often in the fourth decade of life, it is more likely than cancer to be found in young individuals. Many varieties have been recorded but the great majority of the cases are of the round-cell variety; next in frequency come the spindle-cell and lymphosarcomata.

While a very large majority of the carcinomatous growths of the small intestine give rise to obstruction of the lumen, this condition is relatively uncommon with sarcomata.[1] A true stenosis is seldom seen and complete obstruction is very rare. The stenosis, when present, is hardly ever due to a cicatricial contraction such as is commonly seen in carcinoma but is usually caused by a growth in the mesentery or by kinks or adhesions. A small pedunculated growth (these are usually spindle-cell sarcomata) may give rise to an intussusception and secondary obstruction. Dilatation of the intestine, on the other hand, is quite common especially with lymphosarcomata which, as a rule, developing in the submucosa, quickly invade and destroy the muscularis. The dilatation is often bottle-shaped and the wall is thick, whitish and elastic. In widespread or advanced lymphosarcoma of the lower ileum the distended gut may act as a catch basin and at operation be found full of partially digested remnants of food. Obturation is not common. Perforation is rare but has been noted.[2]

The sarcoma is usually single but occasionally multiple growths are

[1] Haggard: Tr. Surg. Sect. of Am. Med. Assn., 1912.
[2] Schmidt: Frankfurter Ztschr. f. Path., 1914, xvi, 1.

present. The progress is rapid and metastases are quickly formed in the mesenteric and retroperitoneal glands, in the omentum, liver and kidneys.

Symptoms.—These are in no way characteristic. At first they are chiefly those of a chronic enteritis—indefinite abdominal pain, dyspepsia, irregular stools, alternate constipation and diarrhea. In rare instances it is the symptoms of stenosis that first appear. A rapid loss of weight and strength is practically always in evidence. Anemia and cachexia are early signs. Unlike carcinoma, it is often the constitutional effect of the growth that is first noticed, the local signs remaining in the background for a considerable time. Frequently the appearance of a tumor is the first sign of sufficient importance to bring the patient to a physician and the tumor may be either a metastasis or the original growth. The patient usually declines progressively and very rapidly, especially with the lymphosarcomata which ordinarily reach a fatal end in about six months. Ascites and edema are rare. There may be a more or less constant moderate elevation of the temperature.

The tumor, when it appears, is firm, nodular, tender and but slightly movable.

Differential Diagnosis.—*Cancer.*—There are no certain means of distinguishing between the early symptoms. Stenosis of the bowel is rare in sarcoma and consequently visible peristalsis and the stiffening of intestinal coil are seen much less frequently. The cachexia and anemia are more marked and more rapidly progressive with sarcoma and the wasting is more marked. The course of cancer is slow; that of sarcoma rapid. The sarcomatous tumor is, as a rule, larger, less circumscribed and of more rapid growth and less freely movable. In patients with suspicious signs, suspect sarcoma where the patient is under fifteen, carcinoma, when over forty. Hemorrhage is less common with sarcoma. A differential diagnosis is often impossible without operation.

Only the combined iliac and cecal form can be mistaken for the tuberculous, the actinomycotic and other chronic inflammatory (chronic appendicitis, chronic pelvic disease, etc.) conditions in the right lower quadrant; with that form this chapter has not to do.

Prognosis.—The prognosis without operation is absolutely fatal. The outlook even with operation is unpromising. The operative mortality is very high because the disease, save for exceptional cases, reaches the surgeon at a late stage and the patient is in poor condition to bear up under the added strain of operation. Recurrences are almost certain to take place.

Treatment.—The treatment is removal of the growth, the section of intestine in which it originates and any removable metastases. This procedure may entail the removal of a very considerable length of intestine and it is often a question of judgment whether it should be attempted or not. Of course, without radical operation, death will certainly and speedily come. If the extent or condition of the original growth or the location of metastases make radical operation impossible

or unwise, a side tracking operation, unilateral or bilateral, may be done. In very advanced cases it may be a question, after the abdomen has been opened, whether to do an enterostomy or to do nothing. The latter course is often the more satisfactory.

The use of Coley's mixed toxins should be a part of the postoperative treatment of every patient upon whom operation is done and it should be advised also in the inoperable cases. Occasionally, surprising cures result.

Temporary improvement in some cases is said to follow the injection of the arsenic compounds or repeated exposures to the roentgen rays. I have no confidence in these measures but anything that promises even temporary relief in this hopeless condition deserves notice.

Gas-cysts (*Intestinal Pneumatosis*) of the lower small intestine have been noted and studied.[1] They are said to be secondary usually to gastric or duodenal ulcer or, at least, to some chronic disease of the intestinal tract. Of themselves, they cause no symptoms and diagnosis is impossible without operation. The treatment is that of the fundamental or predisposing disease. It has been demonstrated both by late operation and by autopsy that the cysts disappear spontaneously.

Equally impossible of diagnosis are those *other cysts of the small intestine*, which are congenital in origin and are probably the persisting relics of the irregular obliteration of the omphalomesenteric duct. They are of clinical interest only because they occasionally cause incomplete obstruction of the intestine.

Effusion into the Bowel Wall Simulating Appendicitis.—I feel that attention should be called to this condition, the favorite seat of which is the lower ileum. There can be no doubt but that there exists this sharply defined, inflammatory condition which is located in the lower ileum and gives a train of symptoms which are in no other way than by operation to be distinguished from acute appendicitis. Riggs[2] cites 4 cases and I have operated on 2 cases yet unpublished. Whether the process is a less severe degree of the so-called phlegmonous inflammation of the intestine which may be present in either the large or the small intestine,[3] or corresponds to the lesion of purpura abdominalis,[4] or is merely an acute follicular enteritis (which is the pathologic diagnosis returned on the specimen which I sent to the pathologist), I am not prepared to say. In the cases mentioned by Riggs and in my own personal cases, the clinical picture presented was that of acute appendicitis. When the abdomen was opened, the appendix was found to be practically normal but the last few inches of the ileum were brawny, reddish-purple and thickened and very sharply defined from the healthy intestine into which it did not merge gradually. The neighboring mesenteric glands were swollen. The affected bowel as I first saw it

[1] Turnure: Ann. Surg., 1913, lvii, No. 6.
[2] Northwest Med., Seattle, 1915, vii, No. 5.
[3] von Saar: Arch. f. klin. Chir., 1914, Bd. cvi, H. 1.
[4] Fromme: Deutsch. med. Wochensch., 1914, xl, No. 20.

made me think immediately of an intussusception that had reduced itself spontaneously. There is no way of making a preoperative diagnosis.

Dr. J. T. Kennedy of the U. S. Navy, in a personal communication, details a fatal case of what was probably purpura abdominalis or else a condition in the small intestine analogous to a gastric one, termed "gastrostaxis" by W. Hale White.[1] An elderly male died in a second attack of intestinal hemorrhage. At autopsy the terminal ileum and ascending colon were found full of blood but a most careful search failed to disclose any intestinal or other lesion. I know of no way of diagnosing such a condition even at operation but it is mentioned for the sake of completeness.

It is a question, of course, if these conditions mentioned above and similar allied conditions are not all members of one group which has as its common underlying state *angioneurosis of the intestine.* The visceral crises in angioneurotic edema are well known and have been studied by several observers.[2] The diagnosis of the condition is a matter of much difficulty. One of the greatest hindrances to diagnosis would be removed, if we could keep in mind the possibility of angioneurotic edema as an occasional active causative factor in abdominal symptomatology. It is very evident that a story indicating previous expressions of angioneurotic conditions (hives, edema, erythema, purpura, etc.), elsewhere in the body will excite suspicion and such a story should be sought for in every instance of indefinite abdominal pain, which may be severe and which does not conform to the type usually recognized as indicating surgical conditions. Acute inflammatory and even obstructive conditions may be simulated. As a rule, the diagnosis must be made by exclusion. The roentgenologic examination is useful in a negative way.

INTESTINAL OBSTRUCTION (ILEUS).

Though this section deals only with the jejuno-ileum, the subject of obstruction must, of necessity, be considered somewhat in its entirety. An attempt will be made, however, to emphasize such phases as have to do in particular with the small intestine, which, by the way, is said to be involved in 90 per cent. of all cases of ileus.

Ileus is a name or term used to designate as a whole that group of symptoms (colicky pain, constipation or obstipation, distention of the intestine, nausea and vomiting), which indicate the existence of an intestinal obstruction. It is not a disease, not a pathologic entity; but it is the expression of a pathologic condition which may vary in degree as it does in its causes. Intestinal obstruction is something with which every surgeon has to deal. Its successful treatment depends to a very great extent on the promptness with which the proper remedial measures are applied.

[1] British Med. Jour., 1910, i, 1347.
[2] Crispin: Collected Papers of Mayo Clinic, 1915, vii.

At the very outset, it should be thoroughly appreciated that absolute accuracy of diagnosis either as to the cause of the obstruction or to its exact situation is not essential. The more fundamentally important feature is the realization of the fact that an obstruction exists. de Quervain expresses it well when he writes, "Our main object must be to recognize when surgical relief should be afforded, although we may not always know the precise position and character of the obstruction." Careful and repeated examinations are by no means to be discouraged but prolonged waiting for the purpose of absolute certainty of diagnosis while irreparable damage is being done to the patient is strongly to be disapproved. Any acute illness characterized by severe abdominal pain, persistent nausea and some degree of shock or collapse and unaccompanied by diarrhea is sufficiently suggestive of intestinal obstruction to warrant operative investigation.

Ileus may be acute or chronic depending upon the completeness, suddenness and permanency of the obstruction. The chronic variety is, of course, for a varying length of time the expression of an incomplete obstruction which under certain conditions may suddenly become complete; the symptoms of acute ileus then supervene; this acute stage may be only temporary (intermittent ileus) or it may be permanent and fatal unless relieved by operation or other procedure. Practically, however, there are to be considered only two main groups of cases:

1. Those with complete obstruction (acute ileus).
2. These with incomplete obstruction (chronic ileus).

Complete Obstruction (Acute Ileus).—Symptoms.—The principal symptom and the one which usually appears first is a sharp pain in the abdomen, diffuse, colicky in character and of sudden onset; it is a severe pain which soon disappears only to appear again with increased intensity; there is little or no tenderness; eructation of gas begins; the patient becomes anxious and the anxiety is shown in the features; during the colic a cold sweat breaks out and the pulse and respiration increase in frequency; nausea is constant; presently vomiting starts and continues; all food or drink taken is quickly ejected; the vomiting may not be violent but it is persistent and uncontrollable; sometimes *early in the course* visible peristalsis, though far more common and more marked in incomplete obstruction, may be present and a coil of distended intestine may be seen or felt to stiffen under the palpating hand, appearing as an area of increased resistance and giving out on percussion a hollow note; the distention may be entirely local at first but in a few hours it grows more general and the abdomen becomes tense; enemata may at first bring away some fecal matter and perhaps a little gas from the bowel but that happens only very early in the attack and they soon have absolutely no effect; examination thereafter shows an empty rectum; there is little or no rise of temperature and the pulse in the early stages is but little disturbed except during the spasm of colic. Unless relief is afforded, the pain after a time gradually ceases but the distention persists and increases, the vomiting continues; the vomitus, consisting at first of the stomach contents and then of mucus

and bile, finally becomes foul-smelling, dark colored and stercoraceous; the features become pinched and sunken, the face pale and slightly cyanotic, the tensely distended abdomen is slightly purplish and abso-

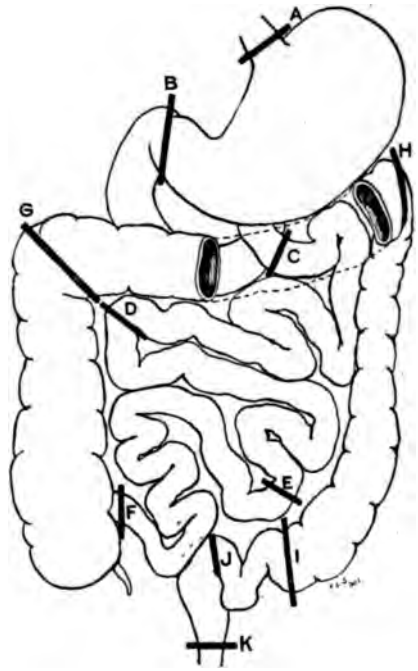


FIG. 2.—Diagram showing usual location of intestinal obstruction. *A*, cardia: Cause, usually cancer, occasionally cardiospasm. No abdominal signs. Regurgitation of food, sometimes showing blood. *B*, pylorus: Cause, stenosis following ulcer, cancer. Possible visible distention of stomach; tumor sometimes palpable. Vomiting of retained food, mucus, fresh and old blood. *C*, duodeno-jejunal junction: Cause, tight duodeno-jejunal fold, arterio-mesenteric obstruction, dilated stomach, hernia into a peritoneal pocket. Epigastric distention, occasionally splashing sounds to right of median line in upper abdomen, vomiting of dark bile and stomach contents. Rapid collapse. *D*, upper small intestine: Cause, band, volvulus, new growth, stenosis following ulceration, internal hernia, occasionally intussusception. Moderate distention usually central, marked visible peristalsis, vomiting of bile and contents of upper intestine. Rapid collapse. *E*, lower small intestine: Cause, as in *D*. Distention central but of greater extent than in *D*. Visible peristalsis, vomiting of bile and intestinal contents. *F*, ileocecal region: Cause, intussusception, band, tuberculosis, cancer, inflammatory mass. Distention, visible peristalsis, etc., as in *E*. *G*, hepatic flexure: Cause, almost always cancer. Distention, if present, is rather general; in many cases tumor is palpable; cecum and ascending colon ballooned; visible peristalsis is uncommon; vomiting of contents of intestine above obstruction; if obstruction is incomplete, at first there may be passage of formed stools. According to de Quervain, 1½ to 2 liters of fluid may be injected into rectum. *H*, splenic flexure: Cause, almost always cancer. Distention general; the ballooned transverse colon is sometimes palpable; tumor only rarely palpable. Symptoms as in *G*. One to 1½ liters of fluid may be injected into rectum. *I*, sigmoid: Cause, almost always cancer, occasionally volvulus, diverticulitis, band. Distention general; cecum sometimes palpable. Vomiting of fecal material. If obstruction is incomplete, constipation alternating with diarrhea. Tumor seldom palpable. One quarter to ½ liter of fluid can be injected into rectum. *J*, upper rectum: Cause, cancer, syphilis, diverticulitis. Signs, etc., as in *I*. *K*, lower rectum: Cause, cancer, syphilis. Tumor usually within reach of finger. Blood in stools, tenesmus, etc. (After de Quervain.)

lutely immobile, the pulse is of low tension and of rapidly increasing rate, the respiration becomes rapid and shallow, the extremities become cold and the toxemic patient soon goes on to death.

A variety of acute ileus is the so-called *strangulation ileus* in which not only is there obstruction of the fecal current but also interference with the blood supply and nutrition of the intestinal wall which quickly leads to gangrene, necrosis and early death. This variety is always accompanied by shock, the severity of which is in direct proportion to the vascular involvement in the obstruction. Strangulation ileus is far more dangerous, more quickly fatal and demands more prompt recognition and treatment than simple *mechanical (obturation) ileus* in which obstruction to the passage of the fecal current is the only threatening factor and which a patient can endure with relative safety for a much longer time. The occlusion of a loop of intestine in a hernia, either external or internal, or its tight constriction beneath an adhesive band are the most frequent causes of strangulation ileus.

In obturation ileus the symptoms are, as a rule, of gradual onset and damage to the bowel wall locally is usually little. It is the form seen in obstruction from gall-stones or other foreign bodies, tumors in the lumen, or tumors originating in other organs and exerting pressure on the intestine, etc.

Acute obstruction involves the small intestine far more frequently than the large. As far as distinguishing symptoms are concerned, in obstruction of the small bowel the pain is more often referred to the region of the umbilicus, the cecum and colon are not ballooned up and the distention is more likely to be central than in the flanks; if the obstruction is very high, the amount of distention may be negligible; in fact, pain, coprostasis and persistent copious vomiting with a flat abdomen indicate obstruction high in the small intestine; vomiting is an earlier symptom and becomes stercoraceous more quickly; the patient fails more rapidly and the collapse is more speedy; suppression of urine is more marked and appears earlier; indican is present in the urine; visible peristalsis and stiffening of the coils are far more common. As the seat of the obstruction approaches the large intestine, the distinguishing signs between obstruction in the latter and in the small intestine are no longer present and a diagnosis cannot be made clinically. The diagram on page 52 and scheme modified from de Quervain summarizes the matter very well.

Differential Diagnosis.—The more common conditions from which acute obstruction must be distinguished are:

General or Spreading Peritonitis.—The diagnosis may be difficult after the second day because the symptoms of both conditions are then very similar. A history pointing to some acute abdominal affection (appendicitis) ushering in the illness is strongly indicative of peritonitis. The pain is more marked in peritonitis and more continuous, the distention is more general and the abdomen more tense; the peritonitic abdomen is immobile and noiseless; visible peristalsis is never present. Early in the course of peritonitis the vomiting is less

persistent. According to Eisendrath, the increase in the pulse-rate is more gradual in peritonitis and there is almost always a rise of temperature. de Quervain lays much stress on the information to be gained from abdominal auscultation. Dead silence in an evenly distended abdomen is a probable indication of a peritonitis; on the other hand, gurgling or metallic sounds heard in one locality in an unevenly distended abdomen point strongly to ileus. Wilms, too, notes the significance of metallic ringing sounds as an early sign of ileus. Careful and repeated auscultation and percussion of the abdomen should never be neglected.

Acute perforation of a Gastric or Duodenal Ulcer.—The history and character of previous digestive troubles are of valuable diagnostic aid and in doubtful cases should be looked into. The initiative pain is sudden, severe, prostrating and the patient is pallid, has a cold sweat and is evidently in collapse. The pain is usually constant and its spread, like that of the dulness and spasm, is along the right costal border into the right flank and thence into the right iliac region. There are usually no periods of relief from the pain. The tense, board-like abdominal wall is very characteristic.

Acute Pancreatic Disease.—This is almost always seen in obese subjects and a preceding history indicating gall-bladder trouble is common. The collapse is more prompt, the pain is distinctly in the epigastric region and is frightfully severe; the face takes on the peritonitic aspect but is usually distinctly cyanotic; the meteorism is less general. The diagnosis cannot always be made without operation. After the peritoneum has been opened, the presence of the white or yellowish-white areas in the omentum, etc., will indicate the diagnosis.

Acute Cholecystitis.—The location of the pain, the tenderness and the spasm are characteristic. There is usually a considerable rise in temperature and, as a rule, a tumor develops very rapidly in the gall-bladder region. A history of previous attacks of colicky pains in the upper right quadrant in common.

Ruptured Tubal Pregnancy.—The menstrual history should be illuminating. In addition to that, the story of a sharp, sudden, stabbing pain in the lower abdomen with the accompanying faintness and pallor should prevent error. Never fail to make a vaginal examination in all doubtful cases.

Tabetic Crises.—The Argyll-Robertson pupil, the Romberg symptom and the absence of the knee-jerk and other reflexes should put us on the right road. Yet the diagnosis may be most difficult, because a paralytic ileus may exist as a manifestation of the tabes or a true mechanical obstruction may exist in a tabetic.

Torsion of Pedicle of Ovarian Cyst.—The pelvic examination and palpation of the tumor should make the diagnosis easy in the early stages; in the late stages, when the abdomen is distended and satisfactory palpation is difficult, the call for operation is so insistent that an exploratory laparotomy will settle the question. Usually after an anesthetic has been given, an ovarian tumor is easily felt.

Acute Appendicitis Sometimes Simulates Acute Ileus.—In my experience I have found this particularly true in patients over thirty. It is usually to be distinguished, however, by the presence of temperature and by the localization of the tenderness, spasm and pain. Leukocytosis is far more common in acute appendicitis. A rectal examination may prove of great value.

Thrombosis or Embolism of the Mesenteric Vessels.—The diagnosis is difficult and often impossible. The symptoms of thrombosis or embolism and those of acute ileus are usually so alarming that surgical interference is demanded in either case and hence the need of accurate diagnosis is not great. Thrombosis and embolism usually occur after fifty; in the hemorrhagic form the presence of blood in the stools may give us a clue but that may not appear for some days.

Renal Colic.—The locality and the radiation of the pain, its distinct limitation to one side, the finding of microscopic blood in the urine, the presence of the Murphy sign, *i. e.*, the demonstration of tenderness by fist percussion over the posterior aspect of the lower ribs on the affected side, and the roentgenological findings are fairly characteristic of this condition and are of fairly constant occurrence. There are usually few or no signs of collapse at the begnining of an attack of renal or ureteral colic.

An immediate diagnosis is not a necessity but a reasonably prompt diagnosis is a necessity. Repeated careful examinations in the course of a few hours are advisable in doubtful cases and almost always succeed in establishing the diagnosis without a loss of time sufficient to be harmful.

The most common causes of acute obstruction of the small intestine are adhesive bands and kinks, strangulation in an internal or external hernia, intussusception, gall-stones and volvulus. Obstruction by round worms has been known to occur but it is very uncommon. Spastic ileus is acute but it is a rare condition and is not recognized except by operation.

The mortality of acute ileus even treated surgically is very high—40 to 50 per cent. Unfortunately, relieving the obstruction does not always save the patient's life.

Incomplete Obstruction (Chronic Ileus).—This may be and often is the forerunner of an acute ileus. The clinical picture is not so well defined; in fact, a very considerable degree of obstruction may exist in the small intestine without giving rise to symptoms sufficiently appreciable by the patient to cause him to seek relief. The fluidity of the contents of the small intestine makes this possible. It may well be the symptoms of the causal condition (as, for instance, the unexplained wasting in cancer), rather than the obstructive symptoms themselves that give anxiety to the patient. A vague abdominal discomfort is often the only early symptom.

As the condition of obstruction develops, however, a definite group of symptoms come well into the foreground:

1. Attacks of *colicky pain* at first followed and relieved by the pas-

sage of gas or of liquid feces. The pain may not be very severe in the early stages but as the condition progresses the pain becomes intense during the attacks and the patient rolls, tosses, sweats and often cries out in his agony. Yet as a matter of early diagnosis, it is not so much the colicky pain in itself that is suspicious but, as de Quervain points out, it is its constant recurrence and its practical confinement to a single locality as well as its final association with

2. Abnormal local distention (relaxation) and stiffening (contraction) of a coil or coils of intestine and a visible and palpable powerful *intestinal peristalsis*—not the slowly progressing, rather widely diffused, almost impalpable, normal vermicular movements of the healthy intestine which are visible in thin persons, but relatively rapidly moving, heaving waves of intense, stiff, cylindrical coils which travel in the direction of and usually cease at a point approximate to the situation of the obstruction.

3. The presence of gurgling, metallic sounds in the abdomen which are often heard by the unaided ear and are frequently noticed and located by the patient himself.

The presence of this syndrome is entirely sufficient to warrant a diagnosis of chronic ileus and of itself justifies the urging of operation for the removal of the cause. Other symptoms are of secondary importance and only indicate an advancing process.

It is in this variety of obstruction in the small intestine that fluoroscopic and skiagraphic methods of diagnosis are of particular aid in disclosing the location and sometimes the character of the lesion.

Meteorism is seldom present to any great extent and it may be entirely absent. When present to any marked degree, it usually signifies the development of a complete obstruction. Constipation may not be a noteworthy symptom especially in chronic obstruction of the small intestine. Occasionally diarrhea and constipation alternate. There is nothing noteworthy about the stools. Vomiting and nausea as early symptoms are unimportant and are uncommon in incomplete obstruction. They are always present during the attacks of colic but are then reflex to the pain. Later, however, as the obstruction becomes more marked, they may be expressions of the obstruction itself. There is rarely any rise of temperature and at first no change in the pulse-rate.

Chronic obstruction may last months and even years without becoming complete. The acute attacks of colicky pain, visible peristalsis, etc., often quiet down and may not reappear until some indiscretion in diet or mode of living causes them to recur. Eventually, as a rule, complete obstruction develops; the symptoms of acute ileus then dominate the picture and demand speedy attention. There is, as a rule, no excuse for allowing the patient to reach this stage, unless, as may happen in rare instances, the attack of acute ileus is the first noteworthy sign of the chronic obstruction.

The most common causes of chronic ileus are strictures (tuberculous, malignant, etc.), chronic intussusception and the adhesion of a loop

to some fixed organ with a gradual decrease in the caliber of the intestinal lumen.

Both acute and chronic ileus may have varied causes and may consequently present varied phases of degree and character. This has naturally led to different classifications based on this or that factor in the cause of the ileus or in its expression. I regard John B. Murphy's classification as so comprehensive and so practical clinically that I shall make use of it here in about the same form as he has presented it in his writings on the subject.

SCHEME.

- **ILEUS**
  - **1. Adynamic ileus (paralytic), symptomatic intestinal obstruction**
    1. Operation on mesentery
    2. Prolonged strangulation
    3. Spinal paralysis from trauma, pathological lesions, etc.
    4. Afferent nerve lesions
    5. Reflex
       1. Strangulation of omentum
       2. Hepatic calculus colic
       3. Renal calculus colic
       4. Torsion of tumor pedicles to degree of strangulation
       5. Diaphragmatic pleurisy
       6. Acute intoxications (typhoid, pneumonia, etc.)
    6. Septic
       1. Local peritonitis
       2. General peritonitis
       3. Embolism (mesenteric)
    7. Uremic
    8. Tabetic crises
    9. Acute pancreatic disease
  - **2. Dynamic ileus (excessive muscular action)**
    1. Spastic, without known cause
    2. Lead poisoning, chronic
       Tyrotoxicon poisoning
  - **3. Mechanical ileus from intestinal obstruction**
    - External (hernia)
      - Inguinal
      - Femoral
      - Umbilical
      - Ventral
      - Lumbar
    - Internal
      - Strangulation
        - Peritoneal and subperitoneal pockets
        - Diaphragmatic hernia
        - Inguinal hernia (internal ring)
        - Umbilical hernia
        - Diverticula
        - Adhesive bands
        - Volvulus
        - Intussusception
      - Obturation
        - Neoplasms
          - Internal
          - External
        - Cicatricial contraction
        - Fecal impaction
        - Foreign bodies (enterolith, round worms)
        - Congenital stenosis

That a clinical distinction between the various varieties is most important, goes without saying. In acute ileus, particularly, laboratory

methods of diagnosis are of no avail. We must make a bedside diagnosis and make it promptly. Whether to operate or not to operate, where to place the incision, what condition to prepare for, what prognosis is probable—all depend to a great extent upon what verbal information the patient gives us and what other knowledge we can elicit with our eyes, ears and fingers. Again I am indebted to Dr. Murphy for an excellent working scheme for the

Diagnosis of Ileus.

I. History.
- (*a*) Previous. (Gall-stone colic? Abdominal operation? Attacks similar to present.)
- (*b*) Present illness
  - (*a*) Mode of onset
  - (*b*) Duration
  - (*c*) Present state

II. Symptoms.
- *A*. Pain
  - 1. Location
  - 2. Character
    - 1. Continuous
    - 2. Spasmodic
    - 3. Intermittent
    - 4. Duration
- *B*. Tenderness
  - 1. Position
  - 2. Degree
- *C*. Nausea
- *D*. Vomiting
  - 1. Time of onset
  - 2. Frequency
  - 3. Persistency
  - 4. Gulping
  - 5. Vomitus
    - 1. Mucus
    - 2. Bile
    - 3. Intestinal contents
    - 4. Feces
    - 5. Blood
- *E*. Pulse
  - 1. Frequency
  - 2. Quality
- *F*. Temperature
  - 1. Primary
  - 2. Secondary
- *G*. Collapse
  - 1. Primary
  - 2. Secondary
- *H*. Stool? (Blood? Mucus?)

III. Physical signs.
1. Face.
2. Skin.
3. Position.
4. Tympanites
   - Local
   - General
5. Irregularities of abdomen (special attention to the region of the external rings and the umbilicus).
6. Tumor
   - Position
   - Mobility
   - Resistance
7. Percussion.
8. Dulness
   - Local: irregular
   - General: changeable
9. Palpation
   - 1. Resistance
     - Regular
     - Uniform
   - 2. Induration
     - Shape
     - Surface
   - 3. Sensitiveness
10. Auscultation
    - 1. Increased peristalsis (local or general)
    - 2. Diminished peristalsis (local or general)
    - 3. Absence of peristalsis (local or general)
    - 4. Induced peristalsis (local or general)
11. Rectal examination. (Invagination. Stricture. Blood.)
12. Pelvic examination. (Tumors.)

Adynamic (Paralytic) Ileus.—Adynamic ileus which is the result of lack of adequate motor power in the intestinal musculature, constitutes a large proportion of all cases of ileus.

It is necessary only to indicate the possibility of such an ileus as a sequence of injuries and diseases of the spinal cord.

Operative trauma of the mesentery as well as prolonged and violent traction on it during abdominal operations is likely to be followed by a paralytic ileus; hence, the mesentery should be handled as little and as gently as possible. Nor must it be forgotten that the mesentery carries both the blood and the nerve supply to and from the intestinal tube. If the former is compromised to any marked extent, not alone paralysis of the corresponding coil may ensue but even gangrene and necrosis.

Insult to the nerve supply is frequently combined with injury to the vascular supply in prolonged strangulation of a coil of small intestine in a hernial sac. This is notoriously true in strangulated femoral hernia. When the constriction has been freed, the coil may appear viable and capable of function and be returned to the peritoneal cavity. Yet a fatal result is not uncommon under those conditions because of a thrombosis of the mesenteric veins or a paralysis of the coil in question. The judgment of surgical experience is a very important factor in the successful handling of strangulated hernia.

Similarly, extreme care must be exercised in the doing of operations for the removal of mesenteric tumors and for the repair of mesenteric injuries. Any serious compromise of the circulation demands intestinal resection rather than mere excision of the tumor or repair of the injury.

Ileus dependent upon any of these conditions is in no way characteristic and the best treatment is preventive.

Reflex Ileus is extremely common. It may appear in the course of such acute intoxications as typhoid fever and pneumonia. It is a not uncommon accompaniment of acute cholecystitis, biliary colic, and renal colic; the characteristic symptoms of these conditions are so familiar to all and are usually so dominating that little difficulty need be experienced in recognizing the causal condition.

In the early stages, certain thoracic diseases such as pneumonia (especially in children) and diaphragmatic pleurisy may be confounded with ileus, chiefly because of the accompanying distention. The presence of temperature with chest conditions and its absence with mechanical ileus should differentiate the conditions. The history of a chill is strongly indicative of pneumonia. But the principal obstacle to diagnosis lies in the fact that we forget the possibility of the expression of thoracic conditions by abdominal sign. Maurice Richardson's way of putting the matter cannot be improved upon: "The diagnosis between acute thoracic and acute abdominal disease is always easy as soon as the characteristic signs of either are apparent. The chief difficulty in making a distinction is to recognize that the necessity for that distinction exists, for the thoracic symptoms are always masked by the more conspicuous and distressing abdominal ones. Once the attention is drawn to the possibility of a thoracic cause, not only for

the thoracic but for the abdominal symptoms, an accurate diagnosis is perfectly easy." It is not possible to overemphasize the advice that every case with abdominal manifestations in which the diagnosis is not absolutely clear should receive not only a careful chest examination but a satisfactory inspection of the throat as well. Septic throat conditions are not seldom accompanied by signs of peritoneal irritation.

Strangulation and torsion of the omentum and marked torsion of ovarian or other tumors may cause or simulate the symptoms of acute ileus; in the omental condition the diagnosis is almost never made except through operation unless the torsion takes place in a hernial sac, when sudden increase in the size of the hernial tumor may indicate the cause. In the early stages of torsion of other tumors the diagnosis is usually possible through palpation but the distention and spasm in the later stages make satisfactory palpation impossible. Under all these circumstances the surgeon is face to face with an acute abdominal crisis and prompt operation is far safer for the patient than prolonged attempts at academic diagnosis.

Paralytic ileus is the constant accompaniment of a general and a not infrequent one of a local peritonitis. It also frequently appears after abdominal operation—*postoperative ileus*—a variety which is of particular interest to the surgeon. It may be of the paralytic or of the mechanical type and the differentiation between these two is a matter of prime importance. The paralytic variety is due to prolonged anesthesia, to operative trauma (whether it be in the shape of careless handling of the coils, undue or prolonged exposure, the unskilful use of retractors, excessive wicking or rough sponging) or to peritonitis. The mechanical variety, while it may have many causes any one of which may be occasionally active, is almost always due to a kink in the small intestine which may be caused by an adhesive band or by inflammatory agglutination of intestinal coils.

My former chief, Dr. John C. Munro, always felt that the most frequent cause of postoperative ileus was a peritonitis of greater or less degree and extent about the seat of operation and I believe that view to be in the main correct. The sepsis usually exists at the time of operation and is spread during the operative manipulations. I also believe that some cases of ileus subsequent to operation on septic foci in the abdominal cavity are manifestations of a general septicemia and that local measures for relief are really useless. We know, however, that many cases recover without secondary operation and that autopsy of some of the fatal cases discloses no peritonitis; hence, there must be a certain number of cases of postoperative ileus in which an infective agent is not active.

How then are we to distinguish the non-peritonitic from the peritonitic type? And the paralytic from the mechanical? The differentiation is easy in theory but difficult and sometimes impossible in practice, since the fundamental symptoms are much the same. Pain, distention, coprostasis, nausea and vomiting are common to all types of ileus. There are, however, certain features which may influence

our opinion in a diagnostic way. The paralytic type (whether non-peritonitic or peritonitic) always appears relatively early after operation, *i. e.*, twelve to forty-eight hours or less. With the peritonitic type, the abdomen is tense, the tenderness is general and the pain, restlessness and anxiety are seen from the first; temperature is always present and vomiting is constant. In the non-peritonitic type (often seen in nervously unstable women), the abdomen is only moderately distended; it feels soft and doughy; the patient does not look peritonitic nor does the condition grow bad so rapidly; the vomiting is less frequent; it is usually easy and not violent and is often unaccompanied by nausea; temperature is often absent and the tenderness is usually not marked; the facial expression is calm and not disturbed. The mechanical variety, as a rule, appears seventy-two hours or more after operation but it may be delayed for weeks and even months. The attacks of colicky pain are severe from the first because of the stormy peristalsis and they usually increase in frequency until peritonitis begins, when they cease; the meteorism is often localized, the degree depending upon the length of intestine above the obstruction; peristalsis may be visible. Borborygmus is always present in mechanical obstruction; if not heard at once, it can be elicited by massage: it is always absent in the paralytic type. The mechanical type shows no temperature. Any case in which symptoms begin after the fourth day may be regarded as of the mechanical variety.

None of these are hard and fast signs of differentiation but they are of value in a general estimate of the condition. The effect of the immediate non-operative treatment of these cases may have some diagnostic value and it is certainly of use as indicating or not indicating the need of a secondary operation. In cases that are not very urgent Gibson attempts to demonstrate the patency or non-patency of the intestinal tract by giving the patient powdered charcoal followed by a brisk carthartic.

Case[1] ascribes the greatest value to the roentgenological examination in the diagnosis of postoperative obstruction of the small bowel. The character and distribution of the gas areas which the abdominal shadow may present will indicate the site of the obstruction. A barium enema may be given to rule out the possibility of colonic obstruction. In a few cases a small quantity of bismuth has been administered by mouth and a picture of the stomach and small intestine successfully taken. I have no doubt that these measures in the hands of an expert like Case is of much practical value but I am of the opinion that they would be of questionable value in the hands of the average roentgenologist. The great majority of surgeons must still look for information to the usual clinical signs.

It is evident that no form of non-operative treatment will be effective in the mechanical variety; operation is essential there. We know from experience, however, that non-operative treatment suffices for

[1] Jour. Am. Med., 1917, lxv, 1648.

the relief of a certain proportion of cases of postoperative ileus. I can see no objection, therefore, to trying non-operative measures for a *reasonable length of time* provided that morphin is not given. At the Carney Hospital a certain routine is followed in the treatment of these cases. Everything is withheld by mouth; salt solution is administered subcutaneously or tap-water is given by rectum. Heat is applied to the abdomen immediately on the appearance of symptoms; both the moist and the dry form of heat have been used according to the preference of the patient. The dry form seems more effective and for this purpose an electric light bath applied locally serves very well; the application of heat to the abdomen should be as continuous as the comfort of the patient will permit; pituitrin (1 c.c.), is given *into the muscle* and is repeated every two hours for three doses. Stomach lavage is practiced for the vomiting and is repeated at brief intervals (every three to four hours). After a lapse of a few hours an alum, an ox-gall or a milk and molasses enema is given. Frequently the use of these means results in the cessation of the vomiting and the passage of plenty of gas by rectum with consequent relief of the distention; this relief, even if but temporary, indicates that there is no mechanical obstruction and that operation is unnecessary. If, on the other hand, in twelve to twenty-four hours, these measures fail to give relief, if the vomiting continues and if the stomach is not washed clean more quickly and more easily at each successive washing (as it should be if we are gaining ground), prompt resort must be had to secondary operation. Do not waste any more time in useless non-operative procedures.

Several courses are then open to the surgeon: (1) enterostomy after the method of Long.[1] This is a first-rate way of providing for temporary intestinal drainage. While the operation can be done without moving the patient from the ward, it is better, as Long advises, to take the patient to the operating room under the plea of dressing the wound. Local anesthesia is to be used; it may be necessary to supplement it with a little ether sometime during the operation. Remove one or more sutures and separate the edges of the incision. General and local conditions will indicate whether an extensive search for the site and cause of the obstruction is warranted or not. Usually it is wise to grasp the first distended coil that presents. Enclose an area at least one-half inch in diameter with a purse-string suture of chromic catgut, taking rather deep bites with the needle. By catching loops of the suture at two equidistant points and holding the untied ends between the fingers, three points of support are secured which will give sufficient tension to steady the parts and to limit the chances of soiling the field. Make an opening through the intestinal wall with a cautery point. Insert a firm rubber tube about twice the size of the opening. The disproportion in size causes the edges of the fistula to hug the tube closely and thus prevents leakage. Now tighten the purse-string suture, at the same time inverting the mucous edges of the fistula. A second purse-string

[1] Jour. Am. Med. Assn., 1917, lxviii, 11.

suture may be laid, if the condition of the bowel wall will permit. Bring the tube out through an opening in the omentum and fasten the tube in place not to the bowel by suture but to the skin by narrow strips of adhesive plaster. Pack the open abdominal wound lightly with gauze as a protective.

2. After picking up the first distended coil of intestine, incise the wall, insert a rubber tube and flush out the bowel thoroughly above and below the opening, and then establish drainage of the lumen through a glass or rubber tube carried over the bed and into a receptacle. The tube may be fastened by one or two sutures to the edges of the opening in the intestine.

3. Under general or spinal anesthesia, open widely the operative wound, evacuate any collection of serum, blood or pus that may be present and search in the region of the operative field for obstructing adhesions or agglutinations.

4. If no local cause be found and if the presence of a mechanical ileus is indicated by the collapsed coils which are always present below an obstruction in the small intestine, then the collapsed intestine must be followed up until the obstruction be found and relieved. It is usually either a band, a volvulus, or an internal hernia. (See pages 66, 67, 68 etc.).

One thing is strongly to be urged. Do not continue non-operative measures too long. Do not rely too much as a favorable sign on the patient's well-feeling after a stomach lavage and on the temporary cessation of vomiting. Pass the stomach-tube again in a few hours; the reaccumulation of intestinal contents in the stomach is of evil portent, means an unrelieved obstruction and indicates the necessity of operation. The best judgment must be exercised in the choice and extent of operations; do not attempt too much. A live patient with an enterostomy is far better off than a dead one with a completed resection and anastomosis. As a rule, the patient's condition will not permit a prolonged search for the cause of the obstruction or a complicated operation for its removal. When the obstruction is purely mechanical and no sepsis is present, greater freedom of search and action is allowable. I agree with Long that enterostomy offers the greatest relief in the cases of mechanical obstruction and not in those cases in which the gut musculature is paralyzed. My own experience with it in the latter class of cases has been disappointing.

Acute dilatation of the stomach is a condition occasionally confounded with postoperative ileus. Such cases of the former condition as I have seen have always, without exception, complained of a constant dragging pain below the left costal border. Even with no other symptom, the complaint of this pain always leads us to pass a stomach-tube and the results are sometimes surprising. The stomach-tube is really our only means of diagnosis as well as of treatment. It should be passed repeatedly, if necessary.

The question of local and general peritonitis will undoubtedly be more fully considered under "Diseases of the Peritoneum." The

diagnosis of the ileus of tabetic crises and that of acute pancreatic disease have already been considered under "Acute Ileus" (page 52).

Embolism and thrombosis of the mesenteric vessels will be considered in the section on "Diseases of the Mesentery," (page 97).

The ileus that accompanies *uremia* is characteristic in no way and diagnosis can be made through a microscopic examination of a centrifulgalized specimen of the urine. The headache frequently accompanying uremic ileus may arouse our suspicion as to its origin.

Treatment of Paralytic Ileus.—For the most part it is merged in the treatment of the causal condition. The variety accompanying pneumonia and diaphragmatic pleurisy responds quickly to the subcutaneous use of morphin. Preventive treatment is of value in that variety secondary to operative trauma; when it continues after the removal of the causal condition or the cessation of its activities, the application of heat to the abdomen, gastric lavage, the use of pituitrin (intramuscularly) and the employment of enemata are our mainstays. I have not been impressed with the value of enterostomy in the treatment of paralytic ileus. If it is to be employed at all, it should be used reasonably early.

Dynamic (Spastic) Ileus.—This is due to a local spasmodic contraction of the intestinal musculature and it may take place in either the large or the small gut. It may occur in ptomain poisoning from cheese, milk, ice-cream, oysters, etc. (J. B. Murphy). It is the variety of ileus seen in chronic lead poisoning. It may follow injury to the abdominal wall or be secondary to abdominal operations. Fromme[1] believes it explains the obstipation in incomplete herniæ where only the cap of a small knuckle of intestine is caught, the remaining free portion being entirely sufficient to allow for the passage of the fecal stream. This unstrangulated part contracts and thus completely blocks the passage. Foreign bodies (worms, gall-stones), within the lumen have been known to cause it. A gall-stone not large enough in itself to cause mechanical obstruction can give rise to complete obstruction through the secondary muscular spasm. It is seen with ulceration of the mucous layer of the gut even when contraction of the healing tissue about the ulcer is by no means sufficient to block the intestinal lumen. It is one of the manifestations of hysteria. Payr thinks that secondary embolic processes may also figure as an etiological factor.

Sufficient has been said to indicate its possible surgical significance. The symptoms usually observed are those of mechanical ileus, However, in the early stages of spastic ileus, especially if a considerable length of intestine is involved, there is not only no abdominal distention but even some contraction of the abdominal wall. Later, a varying amount of distention is always present.

In chronic lead-poisoning, knowledge of the patient's occupation, the presence of the "lead line" on the gums and the history of previous

[1] Deutsch. med. Wchnschr., 1914, xl, No. 20.

attacks may give us a clue. The surgeon will rarely be called in the ptomain-poisoning cases but it is well to bear in mind the possibility of spastic ileus occurring in these.

The diagnosis, however, is possible in only very rare instances except through operation. This is particularly unfortunate since conservative treatment (morphin and atropin subcutaneously) would probably relieve nearly all the cases. In our present state of knowledge exploratory operation is indicated. The spastic condition may let up before our eyes; on the other hand, enterostomy may be necessary.

The possibility of a spastic contraction being the antecedent of some cases of intussusception should be noted.

Mechanical Ileus.—Mechanical ileus is a common form and arises through various causative factors. It may result from conditions within the intestinal lumen, such as foreign bodies, gall-stones, polyps and the various strictures; inflammatory thickening or growths in the intestinal wall itself may be of sufficient extent to cause it; kinking or flattening of the gut by agglutination or by adhesive bands, pressure resulting from growths in neighboring organs, intussusception, volvulus, incarceration and strangulation in external or internal hernia may all play a part and sometimes an important one in its causation.

Symptoms.—The symptoms are characteristic. The pain begins suddenly and quickly becomes severe; persistent nausea and vomiting follow; there is no noticeable change in the pulse at first and never any rise in temperature; tenderness is absent; distention, if present, is local, at least early in the course; palpation of the distended coil may be possible, if the case is seen early; after a few hours neither gas nor fecal matter pass from the rectum, the colic of the powerful peristalsis is marked, the distention increases and is often visible as a local tumor; metallic, ringing, intestinal sounds can be heard; tenderness develops, the vomiting is persistent and there should be no doubt as to the diagnosis long before the appearance of the late symptoms indicating a beginning toxemia. If an uncomplicated obstruction (obturation) alone is present, the symptoms grow worse only gradually and slowly and the patient's general condition may not suffer greatly for some days (two to three days), unless the obstruction is high in the small intestine; but if to obturation strangulation be added, the symptoms are urgent and the downward progress of the patient is very rapid.

Mechanical obstruction involves the small intestine very frequently. The signs and symptoms peculiar to obstruction of the small intestine have already been noted.

External Hernia.—External hernia is a common forerunner of strangulation and in every case of intestinal obstruction the first cause to exclude is strangulation in an external hernia. This exclusion appears perfectly easy but it may be difficult; the absence of a visible tumor in the inguinal region, for example, does not always exclude strangulated inguinal hernia. The possibility of incomplete hernia, properitoneal and intermuscular hernia must be borne in mind. How easy it is to miss an incomplete hernia every surgeon can testify from

experience. Examine the inguinal region carefully. Tenderness or slight resistance about the ring should arouse our suspicions. The small deeply placed tumor of incomplete hernia is easily missed. Do not overlook small umbilical herniæ. Few of us remember to look for lumbar hernia, gluteal hernia or hernia through the obturator foramen as a possible cause of intestinal obstruction of doubtful origin. An obturator hernia is difficult to detect but de Quervain notes that "pain on deep pressure below Poupart's ligament and neuralgia of the obturator nerve—probably called old rheumatism by the patient—warrants the making of a probable diagnosis." Tenderness over any of the abdominal openings should arouse our suspicions. Diagnosis of strangulation in an umbilical hernia is usually easy.

Treatment.—If, after the apparent reduction of a hernia, symptoms of obstruction persist, immediate operation is necessary. Reduction "en masse" is the most probable cause of the continuance of the symptoms, though injury of the mesenteric circulation and consequent paralysis and impending gangrene of the coil is possible.

Attention, however, must be given to the fact that the presence of a hernia (even an irreducible one), does not necessarily mean that it is the cause of the obstruction or necessarily exclude other causes.

Internal Hernia.—Cases of strangulation of the small intestine in internal herniæ are fortunately not common. The symptoms are those of ordinary strangulated hernia and the diagnosis is seldom made before operation. One may suspect but cannot be certain of it. There are no pathognomonic signs.

There are three localities where such a hernia is particularly likely to occur: (1) in the duodeno-jejunal region at or near Treitz's pouch; very occasionally a tumor in the epigastric region and usually somewhat to the left may be palpated and give a clue to the diagnosis; (2) at the foramen of Winslow; (3) into the anatomical peritoneal pockets in the neighborhood of the cecum. Herniæ into peritoneal pockets in the neighborhood of the inguinal ring or into the retrovesical or intersigmoid pockets are known but are relatively rare.

Treatment.—The treatment is the reduction of the contents of the hernial sac and as complete a closure of the opening as it may be possible to carry out. It is to be noted that a complete replacement of an hernia through the foramen of Winslow is not possible. Even a partial reduction is difficult (Moynihan).

It is to be noted that these internal herniæ are often difficult to locate, particularly those at the duodeno-jejunal junction. In cutting the constriction in the last-named variety, extreme care must be taken not to wound the superior mesenteric artery, the inferior mesenteric vein, or the left colic artery, which are the vessels so closely related to the two forms of duodeno-jejunal herniæ. It is to be remembered that the symptoms of acute obstruction in these cases may be due not to constriction at the neck of the sac but to volvulus of the contents of the sac.

That rare form of hernia in which a loop of intestine becomes strangu-

lated in a congenital slit or opening in the mesentery (these are most frequent in the mesentery of the terminal ileum), or the broad ligament is entirely impossible of diagnosis clinically. This is also true of strangulated diaphragmatic hernia, although a roentgenologic examination may provide a means of diagnosis before strangulation takes place; even after strangulation, a fluoroscopic examination may give some useful information.

Adhesive Bands.—Ileus due to constriction or kinking by adhesive bands has no characteristic picture. The history of former attacks of peritonitis or of previous operation for appendicitis or for inflammatory pelvic disease is important, in that it indicates a probable cause for the formation of adhesions. Bands are frequently found in connection with inflammation of the mesenteric glands or with tuberculous peritonitis. They may have their origin too in an adherent appendix or a Meckel's diverticulum. Though any portion of the intestine may suffer, the small intestine and particularly the lower ileum is the favorite location. The bands are usually single and are almost invariably attached by one end to the mesentery. Gibson, however, found more than one band present in about 17 per cent. of a series of 186 cases. Those seen in connection with tuberculous peritonitis are almost always multiple and intricate.

Treatment.—Exposure of the band and the constricted area is desirable, if possible, for accurate knowledge of the condition of the bowel wall is important. Mere severing of the band is not the ideal treatment since it leaves plenty of opportunity for reformation of the adhesion and for further trouble (Moynihan). *Excision* of the band should be done when possible and both ends should be carefully ligatured to prevent bleeding. Adequate exposure of the field is often very difficult because of the distended coils and efforts to expose the band often result either in breaking it, thus adding to the difficulty of accurate localization or in rupturing the distended coil either above the point of constriction or at it; because of the latter danger the peritoneal cavity should be carefully protected against sudden, unexpected leakage of intestinal contents. Necrosis of the constricted portion makes resection of the area necessary, if the condition of the patient warrants; if the condition of the patient is alarming, omentum may be wrapped about the necrotic area or the area itself (if it does not exceed two inches in length), may be invaginated downward into healthy intestine after the method of Summers.[1] Four mattress sutures are inserted above and below the gangrenous area; by pulling upon these and by manipulation the invagination is accomplished.

In extensive obstructive adhesions involving the small intestine resection is not indicated. Under these conditions lateral anastomosis between a coil above and another below the obstructed area or, in certain cases, between the small and the large intestine will give more satisfactory results with far less danger to the patient.

[1] Jour. Am. Med. Assn., 1908, li, No. 6.

Manifestly the best treatment of postoperative adhesions is their prevention or limitation. Absolute prevention of adhesion-formation is impossible and often undesirable. Limitation of adhesion-formation is what should be sought for. To attain this purpose many suggestions have been made. Oils of various kinds (olive, paraffin, etc.), salt solution, cltrate solution, etc., have been left in the peritoneal cavity after operation; the use of animal and other membranes has had its advocates, but the only known successful means of limitation are the employment of omentum or mesentery for covering the denuded areas and the development of a careful operative technic. Careful technic means properly located, generous operative incisions, limited and gentle handling of the coils, the employment of as few as possible walling-off wicks (both these and the sponges should always be moist), as little and as brief exposure as possible, the use of drains protected by a rubber tube or rubber tissue, protection of the coils against irritant solutions (iodin, corrosive, etc.), careful hemostasis, covering denuded areas as fully as possible and accurate approximation of the serous surfaces of the peritoneum. I agree with Summers that the sigmoid has not been used as frequently as it should be for covering open areas in the pelvis. Brinsmade[1] advises the placing of one or two large sheets of gum rubber between the intestinal coils and the walling-off pads or wicks during operation.

Lane's Kink.—The so-called Lane's kink, located in the last two or three inches of the ileum, does not produce complete obstruction but only a stasis of the intestinal contents. The symptoms ascribed to its presence are not characteristic. When possible during a laparotomy, the terminal ileum should be examined; if kinking adhesions are present, they should be excised and any denuded area should be carefully covered. Sometimes it is well to draw up the affected loop by two or three sutures placed between it and the upper (right) peritoneal surface of the mesentery.

Volvulus.—Volvulus is regarded as far more common in the large intestine (the sigmoid particularly) than in the small, though in Ashhurst's[2] experience the reverse is true.

As far as the small intestine is concerned, an adhesive string or a Meckel's diverticulum may provide the factors necessary for the starting of the volvulus. A gall-stone impacted in the intestinal lumen has been known to cause it. Several cases subsequent to appendicectomy have been reported.[3] The volvulus may exist in the form of a twist in the intestine itself or of two coils mutually intertwined (Moynihan) or because of a torsion of the whole mesentery.[4] Usually there is a long mesentery and one or more turns in the loop upon itself. Congenital as well as postinflammatory shortening of the mesenteric root in the vertical diameter, mesenteric tumors, former operation, hernia, habitual constipation, chronic intestinal stasis and a long mesentery are said to

[1] Jour. Am. Med. Assn., 1915, lxv, No. 11.
[2] Ann Surg., 1911, liii, 127.
[3] LeConte: Ann. Surg., 1905, xli, 148.
[4] Weible: Surg., Gynec. and Obst., 1914, xix, No. 5.

be predisposing factors in torsion of the mesentery. The twist is usually in the direction of the hands of a clock and must be about three-fifths of a circle to produce obstruction. Twists of not more than 90 degrees may reduce themselves spontaneously and then recur; the alternate twisting and untwisting give symptoms of chronic ileus.

Symptoms.—The symptoms of volvulus of the small intestine are characteristic in no way; they are those of an acute ileus and are sufficiently urgent from the beginning to demand the laparotomy that will open the way to both accurate diagnosis and proper treatment. Occasionally the localization of the tumor made by the distended coil and the limited tympanites may lead to the making of a probable diagnosis.

Treatment.—Treatment must be determined by the condition disclosed. The first attempts should be in the way of untwisting the volvulus. If difficulty is experienced in this, incision and emptying of the distended coil may be of great help. After reduction of the volvulus the viability of the affected coil must be determined; if the gut is in good condition, it may be returned to the peritoneal cavity; if its condition is frankly bad, if it has been torn in attempts at reduction, or if adhesions make reduction impossible, then resection of the coil in question with immediate end-to-end anastomosis is the ideal operation. However, the condition of the patient may not warrant this and it may be necessary to simply excise the affected portion and make no immediate attempt at suture; a Mixter tube may be tied into the proximal end of the intestine, another into the distal and the operative field sequestrated from the peritoneal cavity. Of course, this procedure necessitates a later anastomosis. An alternative to the procedure just mentioned is to leave the gangrenous coil at the abdominal wound after first walling off the peritoneal cavity with gauze pads and to await Nature's cure by sloughing; the resulting fistula may be closed later. Occasionally in volvulus of the large intestine, unilateral or bilateral exclusion may be necessary. In the small intestine, however, it is only in the most extreme cases that resection and suture should not be attempted, if it is indicated; fistulæ of the small intestine have so many disadvantages and discomforts that every means of avoiding them should be used.

If the volvulus can be untwisted, search should always be made for the cause and that should be remedied, if possible. Mesenteric growths, intestinal tumors and foreign bodies in the lumen should be removed, if present.

In twists and knots of the small intestine which involve a considerable length of intestine a lateral anastomosis which will side-track the affected area is a safe and satisfactory mode of treatment.

The tendency of volvulus to recur is notorious and measures should be taken to counteract it. Suturing the coil to the anterior parietal peritoneum or Senn's procedure of "folding the mesentery on itself in a direction parallel to the bowel and suturing the apex of the fold to the root of the mesentery" may be tried.

The prognosis is unfavorable. A very large percentage of the cases end in death.

Intussusception.—This condition is said to be the cause of 30 per cent. of all cases of ileus. At least, two-thirds of the cases occur in children under one year of age and for that reason intussusception is commonly regarded as a disease of infants and children. Yet, it is sufficiently common in adults for that phase of it to merit our attention. At the Massachusetts General Hospital in the ten years from 1898 to 1908, one-third of the cases was found in adult patients (Codman). Judging from statistics in general, 6 to 10 per cent. is a fair average estimate of its frequency in grown-ups.

Symptoms and Diagnosis.—In infants and young children the symptoms are absolutely characteristic and there is no excuse for failing to make an early diagnosis. The fate of these children with intussusception rests in the hands of the general practitioner, for the mortality is in direct proportion to the promptness of the operation; on that factor and the degree and intensity of the strangulation of the mesenteric circulation depends the patient's chance of recovery. "Symptoms" should not mean, as Clubbe well says, the condition of the child thirty six to forty-eight hours after invagination has taken place but the condition of the child not far later than six to twelve hours after that occurrence. It is the story that the mother tells and not the appearance of the child that should sway our opinions. Stone's description (abbreviated from Clubbe's), of the early case is so graphic that it merits exact reproduction.

"The general appearance of the child is, I feel sure, frequently the cause of mistakes in diagnosis being made by many men. Children in the early hours (six to twelve) of intussusception often do not look sick. Men cannot bring themselves to believe that these healthy-looking, perhaps laughing, babies can have intestinal obstruction. Yet such is often the case. The child at the first onset turns pale, looks very ill, and screams; but it is wonderful how quickly some of them recover themselves. They cry only at intervals, when they get the griping pains, as the intussuscipiens make fresh attempts to force along the intussusceptum."

"The mother thinks nothing of the sudden screaming of the child or of its turning pale; perhaps she has forgotten all about it, until you remind her by your questions. Babies often scream and get pale and vomit and the mother thinks nothing of it but directly she sees blood in the motion she knows something is wrong and hurries off to a doctor as soon as possible. When you are told by a mother that her child has been passing blood, you should always ask certain questions before you send the child away. If you are told that the child was quite well until a few hours ago, when it screamed, turned pale and vomited; that it has been fretful and has vomited a few times since and that it has just passed some blood, you can be morally certain that you have a case of intussusception to deal with; and instead of sending the child away after ordering it some castor oil, you must proceed to verify your diagnosis by careful examination."

Symptoms.—A sudden violent abdominal pain, accompanied by regurgitation of the stomach contents, is usually the first sign and it frequently follows a feeding or a bowel movement in an apparently healthy child. Intussusception, however, sometimes takes place during the course of a diarrhea and should be suspected in a child who, having had diarrhea for some days, seems suddenly to get worse, to be in much pain and vomits; whose bowel movements, after a few hours, instead of being blood stained mucus or feces, contain much more blood and very little, if any, feculent material.[1] The late symptoms are practically those of intestinal obstruction. The child will look sick and show an elevated temperature and a quick pulse; there will be vomiting at frequent intervals, straining and the passing of blood and mucus but no fecal matter and on palpation as a rule an obvious tumor usually on the left side and sometimes to be felt by rectum. Cases that have reached this stage almost always die, whether operated upon or not.

Diagnosis.—The early symptoms in themselves demand a careful physical examination. The child should be undressed and the abdomen gently palpated. Bimanual palpation of the loins should never be omitted, since the tumor, if present, is usually in the course of the colon. If the child screams or resists, examination without an anesthetic is useless and an anesthetic should be given. Under ether many tumors are palpable which would otherwise be impalpable. Indeed, Clubbe advises that in the presence of a suspicious history, an anesthetic should be given in every case where a tumor is not felt, even if the child does not resist. He furthermore remarks that in early cases the tumor is not "sausage-shaped" but more rounded than oblong and about the size of a walnut. In my experience it has been cylindrical in the later cases. In the early cases it will usually be found on the right side of the abdomen or just above the umbilicus; in the later cases, more often on the left side. Occasionally, bimanual examination with one finger in the rectum will disclose an otherwise impalpable tumor. Such an examination should be made in every doubtful case. The finding of the mass completes the diagnosis. The great majority of intussusceptions begin in the neighborhood of the terminal ileum and the cecum.

The finding of blood in the stools adds to the certainty of the diagnosis but blood may be absent in a large percentage of cases until after twelve to twenty-four hours. Previous to that time the stools are apt to be full of mucus (perhaps, blood-streaked or blood-tinged), with little or no fecal material. Recurrent vomiting may or may not be an early symptom. Of course, it is always present in late, neglected cases. Some cases (probably those in which strangulation of the mesenteric vessels is speedy and of marked degree) begin with collapse and have regularly recurring pains which are indicated by moans, drawing up of the limbs and restless movements.

In cases with suspicious symptoms in which careful examination discloses no tumor, skiagraphic plates, after the giving of a bismuth

[1] Clubbe: The Diagnosis and Treatment of Intussusception, London and Edinburgh, 1907.

enema, may indicate the seat and character of the obstruction. But such means are rarely at hand and are not at all necessary to the making of a probable diagnosis.

In adults, intussusception may be acute or chronic and the symptom-complex is neither so clear nor so characteristic as in children. Absence of bloody stools is the rule. This fact is often forgotten. Sometimes the onset of obstruction is acute and sudden; in other cases, the acute onset is preceded by a history of previous attacks of obstruction relieved by medical means or of intermittent attacks of abdominal colic with constipation, separated by intervals of apparent health. Numerous cases have been operated upon with a diagnosis of acute appendicitis. Eliot and Corscaden[1] in a study of adult intussusception were unable to formulate a definite symptom-complex. Undoubtedly, this is because the exciting cause in adults is often a benign or malignant tumor of the intestine or a malignant, tuberculous or other ulceration and the warning symptoms are those of the exciting cause. The inversion of Meckel's diverticulum is a not uncommon cause and the clinical course of an intussusception so caused is exceptionally severe, as a rule.

However, irrespective of the cause of the intussusception or of its form (acute or chronic), "the presence of an abdominal tumor and its variation in size, position and consistency, either during or independent of the attacks of colicky pains, are especially characteristic. The clinical picture of a tumor quickly appearing or increasing in size during the attacks of colic and disappearing or decreasing in size with their cessation renders the diagnosis of intussusception certain" (Eliot and Corscaden). The mass is usually cylindrical or sausage-shaped. Bimanual palpation of the loins should always be carried out and a rectal examination should never be neglected. The course of acute intussusception is more prolonged in adults than in children and the general condition does not fail so rapidly.

Differential Diagnosis.—In children, acute colitis (gastro-enterocolitis) is practically the only condition that may simulate an intussusception: the onset of symptoms in the latter is usually more acute, less insidious and more severe; at times, the child screams with pain but the pain is intermittent and the child has intervals of quiet. In colitis, frequent fecal movements are soon apparent and they continue while in intussusception the obstruction is practically complete in a short time; in the former, the movements are thin and watery at first and later show blood-streaked slime; in the latter, blood may not appear in the rectal discharges for from six to eight hours and, when it does appear, it usually shows in considerable quantity; digital examination may show blood in the rectum—often long before any is passed in the stool (Sheffield.) Occasionally there is a tumor with colitis but it is generally much larger and less definite in shape than that of intussusception (Clubbe).

In adults, intussusception may be confounded with appendicitis. In

[1] Ann. Surg., 1911, liii, No. 2.

the latter, the tumor is usually fixed and the muscular rigidity is confined to the right lower quadrant. The tumor in intussusception is relatively freely movable and the muscular rigidity is generally more marked to one side or the other of the umbilicus.

According to Eliot and Corscaden, the tumor of an intussusception may be differentiated from either a neoplasm or fecal impaction by "the increase in consistency of the mass formed by the intussusception either with the advent of a cramp or even as the result of the mechanical stimulation in the course of routine palpation."

Treatment.—The only safe procedure, once the diagnosis is made, is to open the abdomen. Clubbe advises that one, and only one, forcible enema of warm oil (about 15 ounces), be given on the operating table (always with the child anesthetized), not with the hope (which is only occasionally realized), of entire reduction of the intussusception but with the idea of obtaining as extensive a partial reduction as possible in this way, thus to lessen subsequent manipulation and the shock that always accompanies it. The giving of the enema should be regarded as a step in the operation and not as a curative measure in itself. A laparotomy should always be done, whether disappearance of the tumor follows the enema or not. Before incising the peritoneum, *always have the child well under the influence of the anesthetic so as to avoid sudden eventration which always causes severe shock in children.* The position of the mass in the abdomen determines the location of the incision; when the former is felt on the right side, the right rectus incision should be used; when the mass is not on the right side, the median incision passing to one side or the other of the umbilicus should be employed. In either case, the incision should be a large one.

Further remarks will have to do only with intussusception which affects the small intestine—with cases in which the mass is composed only of small intestine, such cases are rare, and with those in which the small intestine is invaginated into the large the most common form.

First of all, the mass should be delivered as well as possible. Then, reduction by manipulation should be attempted. It is usually successful in early cases (six to eighteen hours). I have succeeded in reducing one case after forty-eight hours. This attempt should always be made by pushing the intussusceptum out of the intussuscipiens, by squeezing from below upward, by "milking" it out. Pulling on the intussusceptum should be avoided as much as possible. It usually results in doing more harm than good. If reduction is impossible by manipulation, the seriousness of the problem is greatly increased especially in infants less than a year old and even in young children. Resection of the whole mass with immediate entero-anastomosis is the ideal procedure and it should be done in adults and in older children. But resection in infants is almost invariably fatal; exceedingly few successful cases have been recorded. This fact may lead us to give more favorable consideration to a procedure that has already been successfully used, viz.: short-circuiting the bowel by an anastomosis around the irreducible intussusception. As another alternative, the mass may be resected

and the open ends of both arms of the intestine sutured into the wound; this, of course, necessitates a second operation for reëstablishing the continuity of the intestinal tract.

When the mass is composed of small intestine only, the bowel may be opened just above the obstruction and a tube inserted. This relieves the obstruction and the danger from toxemia but leaves the intussusception still to be dealt with. It may slough away or it may be removed at a later operation.

Ellsworth Eliot accomplishes practically the same thing in another way. He incises the intussuscipiens near the lower end of the intussusceptum; through this small incision in the gut-wall a soft catheter is inserted and passed through the canal of the intussusceptum into the unaffected gut above; the incision in the gut is then sutured to the abdominal wound whence the other end of the catheter emerges.

Clubbe advises immediate resection and end-to-end anastomosis. This may be done in the ordinary way, by suture or with a small-sized Murphy button, or Barker's procedure may be used either in infants or in adults. The latter unites by a continuous circular suture the intussusceptum to the intussuscipiens at the point where the former enters the latter; the intussuscipiens is then opened on its free margin and the intussusceptum delivered and excised; through-and-through suture of the stump is done and the stump is dropped back into the lumen of the intussuscipiens; the incision in the latter is then closed.

Whichever procedure is adopted, the outlook is grave. Cases in which reduction is impossible are late cases and the mortality must remain high. Early diagnosis is the best treatment. Fortunately, in case reduction is successful, it is only rarely that the gut is not viable.

Clubbe advises against the use of drainage after resection. In adults, after reduction, search should be made for the probable cause, frequently an intestinal tumor, of the intussusception. The cause, of course, should be removed, if possible.

After-treatment.—Care should be taken to see that the abdominal bandage is firmly applied. Energetic measures to combat the shock should be adopted. Small doses of morphin should always be given. Clubbe advises that all infants, whether they were breast fed before operation or not, should be put on artificial feeding for forty-eight hours. An enema may be given twelve hours after operation and repeated, if there is abdominal distention.

The adoption of measures for preventing recurrence is not advised by Clubbe and he regards such measures as meddlesome, unnecessary surgery under the conditions usually existing. Cubbins believes that placing the terminal ileum for a distance of four or five inches parallel to the ascending colon and holding it in that position with a few sutures will prevent the recurrence of intussusception. This procedure is very simple, quickly done and will not add materially to the length or shock of operation.

Obturation Ileus.—Some of the causes of obturation ileus have already been touched upon. Fecal impaction never occurs in the small

intestine. What has already been said of congenital stenosis (page 17) will suffice. The signs and symptoms indicative of neoplasms (page 44) need no further elaboration here. Cicatricial contractions give no pathognomonic picture. Tumors outside the small intestine sometimes press on it, kink it or involve it; obstruction may ensue but the diagnosis of the cause will be made only at operation.

It remains to refer briefly to ileus produced by a foreign body in the lumen of the small intestine. Swallowed objects sometimes play a part here and in such cases the patient's story usually indicates the cause of the symptoms. Cases of obstruction of the small intestine by an enterolith (usually originating in a diverticulum), have been recorded. The most frequent foreign body and practically the only one of peculiar surgical interest is seen in a gall-stone, which, ulcerating through the gall-bladder or common duct (rare) into the duodenum, works its way along through the small intestine finally to become lodged at some point or other and to produce the picture of intestinal obstruction.

Though the stone occasionally lodges in the jejunum, its most frequent resting place is the lower ileum. The patients are usually women at or after middle life.

The diagnosis is seldom made before operation. The history of preexisting symptoms of gall-bladder disease is, of course, the most striking indication of the cause of the obstruction but in the stress of her present trouble the patient frequently forgets to mention it and the surgeon to seek for it. Even when sought for, it may be found wanting in half the cases. Moller[1] in a series of 22 cases, reports a history of preëxisting cholelithiasis in only 11 (typical in 6, vague in 5 cases). The symptoms are the usual ones of mechanical obstruction. As a rule, the onset is gradual unless the stone be lodged in the jejunum; then intense, colicky pain will appear suddenly, with marked collapse, little distention and the early appearance of vomiting which is persistent and quickly becomes feculent. In all cases, the attacks of colicky pain with remissions and recurrences are the characteristic early feature; visible peristalsis may be present; nausea or vomiting is always in evidence and distention is seen when the stone is lodged in the lower ileum. There is no distinct diagnostic picture. The roentgen ray is of no special value (Frank Martin). At best, only a probable diagnosis can be made clinically. Accurate diagnosis is not necessary. The important thing is to determine that mechanical intestinal obstruction from some cause is present and to urge immediate operation.

Treatment.—The only sane treatment is early operation and removal of the cause. Even with the abdomen opened discovery of the stone is not always easy. Look for collapsed coils of small intestine and follow them up until you find the obstruction. The stone of itself may not be large enough to block the lumen entirely but the spastic contraction of the intestinal wall down on the stone may complete the obstruction. Occasionally ulceration follows the impaction of the stone and per-

[1] Quoted in Prog. Med., 1913, iv, 85.

foration may occur into the free peritoneal cavity or into a neighboring coil. Rarely a diverticulum forms in which the stone may rest for a time. The intestinal wall over the stone should be incised and the stone removed. Drain out the toxic contents of the coil above the obstruction and close the intestinal incision.

Usually a single stone is found but occasionally more than one stone has escaped from the gall-bladder into the intestine and, unless found and removed, may cause later recurrence of the obstruction. Dr. B. G. W. Cushman of Auburn, Maine, tells me that he removed a gall-stone which had lodged in the small intestine four feet from the stomach. Twenty-five days later recurrence of symptoms of obstruction led him to reoperate and he removed a second stone, evidently a portion of the other, which had become impacted at the seat of the former enterotomy. The patient survived both operations.

The mortality in these cases is still high and will remain high until we learn to make an *early probable* diagnosis of intestinal obstruction and to act accordingly.

Angioneurotic Edema (see page 51).—Angioneurotic edema is supposed to cause intestinal obstruction occasionally. The obstruction is not permanent. Only a probable diagnosis can be made. The occurrence of transient swellings or other expressions of angioneurosis elsewhere in the body gives us the only possible clue.

General Remarks on the Treatment of Acute Obstruction of the Small Intestine.

As a preliminary to all such operations, the stomach-tube should be passed and the stomach thoroughly washed out. The operative technic naturally varies greatly with the cause of the obstruction and with existing conditions. First of all, the obstruction must be located. With distended intestinal coils, this is not always easy. Total evisceration is not desirable for obvious reasons but it cannot always be entirely prevented. Avoid it when possible. When it occurs, cover the coils with moist warm towels and keep this covering moist and warm with hot solutions. Do just as little handling of the *small intestine* as the nature of the case will permit. Handling of that portion of the intestine adds greatly to the shock, while the large intestine may be handled with comparative impunity.

In searching for the point of obstruction, if it is not apparent at once, locate the collapsed coils. If collapsed coils of small intestine are seen, the obstruction lies above the ileocecal valve. That point is usually easily found; the terminal ileum is picked up and the intestine is passed rapidly between the fingers. As it is handled it is replaced in the peritoneal cavity. As a rule, the obstruction is soon located and proper measures for its relief may be carried out. Usually, collapsed coils are not seen at first; in that case, too, locate the cecum. An undistended cecum indicates obstruction in the small intestine and examination of the ileum may be started in the manner previously indicated.

Very often the obstructed coil lies in the pelvis and it is well to introduce the hand into the pelvis at first. In case the cause of obstruction is not readily determined, the umbilical and the inguinal openings and the common locations of internal herniæ should be quickly examined from within.

Distended intestine must be handled gently. It is easily torn and with disastrous results. It is often necessary to empty the full, distended coils to facilitate examination. This may be accomplished in various ways. Monks has suggested the use of a long glass tube introduced through a small opening in the bowel. Upon this tube the coils may be "gathered up"; the contents flowing through the tube are conducted through a long rubber tube into a basin on the floor. In my experience the successful employment of this procedure is not very easy; Ashhurst has found it impossible to crowd more than two feet of intestine upon the tube at one time. The use of a fair-sized trocar and cannula and a purse-string suture is often effective for the purpose of emptying the coils. By manipulation a considerable length of distended intestine may be thus drained; as the cannula is withdrawn, the purse-string suture is tightened and the opening in the intestinal wall closed. Of course, repeated introductions of the cannula at various places are necessary.

The most perplexing problem in the surgery of obstruction of the small intestine is the determination of the best means of combating the effects of the virulent toxin in the contents of the bowel above the obstruction. The toxemia which follows the entrance of this poison into the general circulation is the most frequent cause of death in cases of obstruction. The recent investigations of F. T. Murphy and Brooke[1] indicate that this toxin passes through a damaged mucous membrane only and not through the normal intestinal mucous membrane. The only rational conclusion from these experiments, therefore, is that in the surgical treatment of cases of intestinal obstruction that part of the intestine with a mucous membrane so damaged as to permit of abnormal absorption should be resected rather than drained. This would be ideal treatment since it would do away with the necessity of enterostomy; but, unfortunately, it brings up the difficult problem of finding out just how much intestine is sufficiently damaged to demand resection.

Our present methods of procedure seem to be limited to thorough evacuation of the poisonous contents of the distended loop at the time of operation and, after operation, repeated gastric lavage, the giving of large quantities of salt solution intravenously or subcutaneously and in late cases the placing of a tube in an enterostomy opening above the point of obstruction for the purpose of draining the obstructive products to the surface. In very early cases (twenty-four hours or thereabouts), especially in cases of low obstruction it is probably not necessary to perform enterostomy but in the later cases of complete obstruction, enterostomy is usually a necessity, whether resection is done or

[1] Arch. Int. Med., xv, No. 3.

not. In any event it is well to remember that to try to sew the cut end of a thickened, contracted intestine to that of a damaged, distended one is poor and usually unsuccessful mechanics. Draper[1] has advised the use of an emulsion made from the epithelium of the small intestine of dogs and has employed it successfully in one case. The emulsion is placed in the stomach and should probably be also used in colonic irrigations. Vaccines made from the duodenal and jejunal mucosa of healthy animals have been suggested by Eppinger and Guttman for use in cases of obstruction. McKenna[2] claims success in these cases of ileus by draining the duodenum through an enterostomy opening placed high in the jejunum. I have had no experience with either of these suggested means but I consider McKenna's suggestion worthy of trial.

The disadvantages of an enterostomy opening in the small intestine are many. A long existing opening means a greater or less degree of starvation of the patient, a bothersome irritation of the skin about the wound and often a more or less dangerous operation for its closure. In order to make the reëstablishment of the continuity of the intestine more simple, S. J. Mixter, following the von Mikulicz idea, has practiced "stitching the walls of the small intestine together for three or four inches, thus making a sort of double-barrelled gun with the opening on the surface. A pair of clamps applied later in the old-fashioned manner of cutting the spur, is sufficient for the free passage of the fecal stream and the spontaneous closure of the external opening. If the external opening does not entirely close, the bowel is able to pass along most of its contents and a comparatively slight and safe operation completes the cure."

That there are some disadvantages connected with this procedure is evident and to avoid them Shoemaker[3] made use of the following expedient, the idea of which had previously been advanced by Maydl: "After resecting all gangrenous and obstructed intestine, using a Murphy button he placed the cut end of the distal end of the intestine in the side of the proximal fragment about six inches from its cut end; this free proximal fragment was then drawn through a stab wound made in the abdominal wall as far away as possible from the original incision. A drainage tube three-eighths inch in diameter was tied in the open end of the gut and carried over the bed into a bottle. The original incision was closed." Fecal contamination of the skin will not begin until about the sixth day, when the extruded portion of the intestine will slough away at the level of the skin. Then, under nitrous-oxide anesthesia, the bowel is drawn further through the stab wound, crushed, tied and cauterized; the stump is invaginated after the manner of invaginating the appendix stump and will then slip back into the peritoneal cavity. To add to the margin of safety, the stump may be fastened with a single stitch to the peritoneum, thus providing for egress of fecal leakage, if it should occur.

[1] Jour. Am. Med. Assn., 1914, lxiii, No. 13.
[2] Surg., Gynec. and Obst., 1913, xvii, No. 6.
[3] Ibid., 1917, xxv, No. 2.

An enterostomy may also be done with a rubber tube in a manner similar to that of the Witzel gastrostomy; this decreases at least temporarily the amount of leakage on the surface of the abdomen and thus lessens greatly the patient's discomfort; personally, however, I prefer the method of Long (page 62).

The irritation of the abdominal wall may be much diminished by frequent dressings and the free applications of zinc oxide ointment or compound tincture of benzoin.

The use of drugs (eserine, pituitrin, etc.), for stimulating intestinal peristalsis has not always been satisfactory in my experience but they should always be given a thorough trial.

As far as anesthesia is concerned, a simple enterostomy may be done under local anesthesia. More extensive procedures should be carried out under spinal anesthesia with tropococain or under a general anesthetic.

Replacement of Eviscerated, Distended Intestine.—This is often tedious and difficult. Repeated puncture of distended coils for the purpose of lessening the bulk is sometimes advisable and the so-called "towel" method is of great help. Cover the whole eviscerated mass with a large, hot towel and place the edges of the towel inside the wound margins. Elevate the abdominal wall with retractors, press the edges of the towel well within and under the wound margins and gradually force the contents of the artificial hernia thus produced into the abdominal cavity. Once the coils have been replaced, they are usually easily held by a moist pad, while sutures are inserted. As the sutures are tied, the pad is withdrawn.

INTESTINAL FISTULÆ.

Enterovesical Fistula.—Fistulous communications between the jejuno-ileum and the kidney or ureter are recorded but are so infrequent as to be negligible. Similar communications are relatively frequent, however, between the *ileum* and the bladder (enterovesical fistula). The opening is practically always on the side or posterior wall of the bladder; it is usually single. By far the most frequent cause is tuberculous or malignant disease of the intestine. Acute inflammatory disease (sometimes) and syphilis (rarely) play a part in the etiology. Bladder conditions are very seldom the primary cause of the fistula.

Symptoms.—The attention of the patient is usually called to the condition by the symptoms of cystitis and the passage of gas through the urethra during or after the act of urination. Macroscopic examination of the urine indicates the presence of fecal or purulent matter and the microscope confirms this. J. B. Murphy regards as the best means of establishing a diagnosis the "strawberry-diet" test; the seeds pass into the bladder and are found in the urine. The diagnosis is usually not difficult and is readily confirmed by the cystoscope; a patent urachus and a bladder diverticulum must be excluded.

Treatment.—In the rare syphilitic cases, appropriate medicinal treatment may succeed but, in the usual enterovesical fistula, operative treatment is necessary. A laparotomy should always be done that the character and extent of the condition may be determined. Resection of the involved coil of small intestine and of a portion of the bladder wall with intestinal anastomosis and repair of the bladder wall is the ideal procedure; for the infiltration about the fistulous opening in the small intestine makes the simple closure by suture very insecure; but widespread adhesive formation and the nature and extent of the primary disease may make the ideal operation difficult or even impossible. It should, however, always have first consideration.

The very first step in an attempt to repair these and other similar fistulæ is a sufficient freeing of the intestine from adhesions to the surrounding parts. In J. B. Murphy's opinion failure to get sufficient liberation is the most common cause of unsuccessful operative results.

The operation of next choice is that of bilateral exclusion.

Postoperatively, the bladder should have continuous drainage and careful irrigation for at least two weeks.

Fistulous communications between the small intestine and the vagina, uterine cavity and very rarely a Fallopian tube are known. The ileum is the portion of the intestine most frequently involved and the cause is not uncommonly of intestinal origin (tuberculosis, appendicitis and its sequelæ, malignancy, etc.).

Enterotubal fistulæ are so rare that they may be disregarded here. *Enterovaginal* are the more common; injuries during parturition or during a vaginal hysterectomy are the usual causes; *entero-uterine* fistulæ commonly result from prolapse of a coil of gut after manipulations during labor or attempted abortion, from accidents of curettement and often from a retained or necrotic fetus or portion of a fetus. The existence of such fistulæ is indicated by the escape of gas and intestinal contents from the vagina.

Attempts to close enterovaginal fistulæ from below are so uncertain that they should not be made. An abdominal operation should be done. The intestine should be sutured or resected as conditions demand and the vaginal opening may be used for the purpose of drainage. Occasionally, bilateral exclusion is necessary. If a pathological cause is present, it should, of course, be removed. In the entero-uterine variety, also, laparotomy is indicated and the surgical procedure must fit itself to conditions found.

Intestinal Fistulæ Opening on the Surface of the Anterior Abdominal Wall.—The usual antecedent of this type of fistula is operation for a neglected case of appendicitis or for the drainage of an intra-abdominal abscess. Very often the cause of the fistula is not the operative procedure but the necrosis of the gut wall due to the infective process. Operative trauma and interference with the blood supply of the intestine are also frequent causes. Long-standing fistulæ occasionally result from the necessity of doing an enterostomy as a life-saving

measure. The higher in the small intestine is the location of the fistula, the earlier should be the attempt made to close it.

As a relieving measure and sometimes as a curative measure in fistulæ high in the small intestine, the use of a rubber T-tube, similar to the one adopted by Kehr for drainage of the biliary passages, has been successful. It is inserted in the intestinal fistula and held in place by gentle traction. The fecal current passes through the horizontal arm of the T (Kappis[1]). This expedient should certainly be tried in desperate cases as a supportive measure. Constant drainage by some sort of suction apparatus has also been suggested as a means of relief and even of possible cure.

Fistulæ of the small intestine are more easy to treat operatively than those of the large intestine. In the simple forms it is necessary only to dissect up and trim the everted mucous edges and, after freeing sufficiently the intestinal wall, to close the opening by a suture applied usually at right angles to the long axis of the intestine. Care must be taken not to obstruct the lumen to too great a degree. Occasionally, resection of a small piece of intestine followed by an end-to-end or a lateral anastomosis must be done.

The more complicated forms must be approached in a different way. The fistula must be isolated from the entire thickness of the abdominal wall through an incision surrounding it. It is packed, wrapped in a moist wick and clamped so that leakage may be avoided. Then the surrounding parts must be cleansed with tincture of iodin and shut out of the field by towels. The peritoneal cavity is then opened deliberately and carefully protected with moist wicks. The involved coils are freed from all adhesions to the anterior abdominal wall and to surrounding sound loops and organs; when isolated, the mass should be lifted out of the abdomen; the separation of the individual loops is thus rendered much easier. As each loop is separated from the mass, it should be inspected; perforations, if they exist, should be closed and denuded areas peritonealized as well as possible. Finally the sinus itself is excised and the coil or coils into which it leads are closed by suture or are resected, as may seem advisable. Several openings into a relatively short length of intestine necessitate resection rather than suture. If a fistula has existed a number of months, the intestine below will often be collapsed. A lateral anastomosis after resection is much safer under such conditions. In infected cases, intestinal sutures should be of chromic catgut rather than of linen because of the danger of sinus formation from the latter. Linen, if used, should be covered in by a row of catgut sutures (J. B. Murphy).

The closure of an artificial opening in the small intestine may, however, present great difficulty because of secondary adhesion formation; the separation of these adhesions is difficult and may lead to later intestinal obstruction after the fistula has been closed. Under such circumstances, even after resection a subsequent anastomosis

[1] München. med. Wchnschr., 1911, lviii, No. 1.

between the ileum and transverse colon an ileosigmoidostomy may be necessary. The possibility of these really dangerous complications and sequelæ has led Moynihan to prefer a cecostomy to an ileostomy when the former would serve the purpose, because adhesions following it are far less widespread.

INTESTINAL OPERATIONS.

The operative procedures most commonly used in connection with the small intestine will be briefly indicated. No attempt will be made to include all the many operations that have been devised in this field but I hope to set forth briefly and simply the technic of the very few fundamental procedures necessary for the practical surgeon to know.

Intestinal Localization.—As a preparation for the undertaking of of any operative work on the small intestine a fair knowledge of intestinal localization is desirable. It is well that a surgeon should know, at least approximately, to what portion of the intestine a presenting coil belongs and which is the proximal and which the distal part.

The coils of small intestine are very movable but there is at least a relative regularity in their disposition because of the arrangement of the mesentery. In a general way the uppermost third of the intestine occupies the upper left quadrant of the abdomen; the middle third is usually found in the middle of the abdomen and in the left iliac fossa, while the lowest third occupies the right iliac fossa and the pelvis the terminal ileum rising out of the pelvis to join the cecum. This is roughly the general arrangement, but it is to be remembered that adjacent coils should not be assumed to be continuous (Piersol). Sernoff estimates that 41 per cent. lies on the left side above the pelvis, 41 per cent. in the pelvis and only 18 per cent. on the right side. Only about one-third of the small intestine rests directly against the abdominal wall and such coils usually, but not always, belong to the ileum.

A loop of intestine presenting in an incision located in the upper abdomen especially in the middle line or to the left of it may be regarded as of the uppermost third of the intestine; an incision in the mid-abdomen to the left of the umbilicus will disclose loops belonging probably to the middle third; while, in the very commonly employed mid-line incision below the umbilicus or that through the lower right rectus muscle, coils from the lowest third usually present.

The small intestine decreases from above downward in caliber, in the thickness of the wall and in vascularity. The vessels of the upper portion of the mesentery radiate chiefly from primary vascular arches and are larger, longer and straighter than corresponding vessels in the lower portion, where small, short, tortuous branches spring from secondary or even tertiary arches.

Monks[1] to whom we owe much of our knowledge of intestinal localization calls attention *to a method of determining the real direction*

[1] Tr. Am. Surg. Assn., 1903, p. 405.

of the bowel in any given loop. The abdominal wound should be sufficiently large to permit palpation of the root of the mesentery. The loop in question is drawn well out of the peritoneal cavity and held by an assistant so that there is no twist in the mesentery; then, by "straddling" the loop with thumb and fingers, the direction of the mesentery and consequently that of the bowel is readily ascertained, for the upper right side of the mesentery will be easily distinguished from the lower left side.

The mesentery in its course divides the lower abdomen into two unequal spaces, the left, which is the larger and the lower, passing down uninterruptedly into the pelvis, while the right, the upper and

FIG. 3.—Jejunostomy: First step, showing catheter introduced into upper jejunum and fastened with a single suture. (William J. Mayo.)

much smaller, terminates below in the right iliac fossa. This fact has a practically important bearing on the *direction of the path followed by an exudate*, hemorrhagic or purulent, in certain regions of the peritoneal cavity (Gwilym Davis). Bleeding, etc., originating in the right and upper quadrant of the abdominal cavity tends to pass over the intestines and to reach the right iliac fossa, while bleeding, etc., originating in the left and lower quadrant tends to pass under the intestines and to collect in the left iliac fossa and in the pelvis.

In searching for the *source of a concealed hemorrhage* the small intestine should first be pushed downward and to the left and the right side of the abdominal wall lifted with retractors to permit examination

of the right abdomen; that completed, the intestine should be pushed upward and to the right so that the left abdomen may be explored. (Gwilym Davis).

FIG. 4.—Jejunostomy: Second step, showing infolding of catheter. (William J. Mayo.)

Jejunostomy.—There are many indications for the employment of jejunostomy, most of which have to do with gastric conditions. In patients too weak from starvation to bear extensive gastric operations, in very extensive ulcerative or cancerous disease of the stomach, in recurring hematemesis for which even operation shows no cause, in generally contracted stomachs, in persistent vomiting, as the pernicious vomiting of pregnancy, threatening life, in accidental injuries to cancerous stomachs which cannot be fully repaired, in large duodenal fistula

which cannot be closed, jejunostomy is indicated. In all cases in which rest of the stomach and duodenum together with improvement in the general nutrition of the individual is desired, jejunostomy is the best means at our disposal. It may be a palliative, preparatory or supportive measure.

The so-called Witzel jejunostomy is the form in most common use. The abdomen is opened through a left rectus or a median incision in the epigastric region. The duodeno-jejunal fold is recognized and the jejunum picked up and slipped between the fingers until a point 12 to 16

FIG. 5.—Jejunostomy: Third step, operation completed; jejunum fastened to abdominal wall. (William J. Mayo.)

inches from the fold is reached; here the intestine is opened sufficiently to allow a rubber catheter (No. 17 F.) to be introduced; the catheter is passed for a distance of three inches in a direction distal to the opening; a single chromic catgut stitch passing through the intestinal wall and the catheter closes the intestinal incision about the catheter which is now infolded in the jejunal wall for one and one-half inches by linen mattress sutures (Figs. 3, 4 and 5.) The intestine is then fastened to the parietal peritoneum in the lower angle of the wound by two or three linen sutures and the abdominal wall closed in the usual way.

Any food in liquid form can be introduced through a syringe or by

means of a funnel attached to a tube just large enough to slip over the projecting end of the catheter. Feeding may be frequently repeated (according to indication) and continued for weeks in this way without leakage or regurgitation. If the catheter slips out accidentally it should be replaced within a few hours, not more than twelve, lest the artificial tract should become obliterated.

Ileostomy.—Ileostomy is usually done for the purpose of temporary drainage of the small intestine. It is chiefly indicated in cases of acute intestinal obstruction where the speediest, simplest manner of giving relief must be adopted, where search for the cause of obstruction would mean too great shock to the patient or where, even with the cause of obstruction removed, the toxic content of the obstructed intestine must be drained off. In certain cases cecostomy may be substituted for it. Recently a further indication for the use of jejunostomy has arisen. Most of the acute colonic infections and many of the slowly progressive chronic ones which do not yield to medical measures (colonic vaccines, etc.), are surgical diseases.[1] In most of them an ileostomy is indicated; an occasional case with an inflamed, thickened, chronically infected, dilated cecum, often with a mesentery showing enlarged lymph nodes, demands removal of the terminal ileum, cecum and that part of the colon supplied by the right colic artery. In multiple polyposis, a condition which Draper and Lynch look upon as secondary to an infection, ileostomy will bring relief. A new field and probably a wide one is thus opened for ileostomy. How valuable the procedure will prove only experience and an honest study of after-results can tell. It is a new candidate for honors in the field where total colectomy and ileosigmoidostomy have been successful only occasionally. It may be done in a manner similar to that already described for making a jejunostomy; Long's method (page 62) may be employed or the following method (after Moynihan) be used. It is unnecessary to emphasize the desirability of placing the opening as low as possible in the small intestine.

When the abdomen is opened, draw up a distended coil of gut and fix it to the abdominal wound which should be about two and one-half inches in length by two sutures, one at each end, which pass through all the layers of the abdominal wall on each side and through the serous and the muscular coats of the intestine. These are left untied temporarily. Then, with hemostats, bring into prominence the peritoneal layer of the abdominal wall and to it with a continuous suture of linen sew the serous coat of the intestine taking an occasional bite through the muscle or aponeurosis, but never the skin, of the abdominal wound. The through-and-through sutures are then tied and the bowel may be opened immediately, if necessary. It is better to wait three or four hours, if possible, that protective adhesions between the visceral and parietal peritoneum may form. When the bowel is opened, a Mixter tube should be introduced and held in place by a previously laid purse-

[1] Draper and Lynch: Jour. Am. Med. Assn., 1915, lxiv, 1788.

string suture. Leakage will thus be prevented for three or four days, when the tube will work out and the ordinary measures (zinc oxide ointment or compound tincture of benzoin), for protecting the abdominal wound must be brought into use.

Moynihan's method will do very well for such cases as have need for an ileostomy opening that will have to be in use for a considerable length of time. Long's method is to be preferred for such cases as need drainage of relatively short duration.

Intestinal Resection.—As far as the small intestine is concerned, resection may be necessary for injuries (caused by a blunt force or a penetrating agent), for the repair of fistulæ made designedly or occurring accidentally, for growth or stricture (malignant disease, tuberculosis, etc.), for intussusception, for mesenteric tumors, for disease involving the blood supply of the intestine, for gangrene dependent upon strangulated hernia, bands, volvulus, etc., and for damaged intestine in acute obstruction.

Of course, the general principles covering the operation of intestinal resection are the same in all instances but the wide variation in the conditions that make the operation necessary, unavoidably cause some variation in the steps of the operative procedure.

Many ingenious methods of intestinal resection and suture have been proposed and many artificial aids, the best of which is the Murphy button, have been invented for hastening the process or rendering it more easily accomplished. Nevertheless, each surgeon should perfect himself in the technic of one method of doing an end-to-end and one method of doing a lateral intestinal anastomosis. The method should be simple, safe, rapid and independent of special complicated devices and instruments. Other than clamps—and even these may be dispensed with in case of necessity—artificial aids to intestinal anastomosis are rarely necessary. The suture methods take but a few minutes longer and are far safer and more satisfactory. The very occasional patient whose condition is so alarming that these few additional minutes may not be taken requires not a resection, as a rule, but an enterostomy. A surgeon who is familiar with the essentials of the suture method is never at a loss of means to carry it out provided he has a needle and thread and even a meager kit of instruments. Clamps are extremely useful but not absolutely necessary.

Little need be said of the technic of lateral anastomosis. The procedure has been illustrated so well and in so many articles and its performance is so common now-a-days either in gastro-enterostomy or similar operations that it would be a waste of time to reproduce its steps again. It is used less frequently in surgery of the small intestine than in that of the large; but, despite some objections that have been urged against it, I feel that there is a place for the lateral operation in surgery of the small intestine. In my experience its use has been followed by no unpleasant after-results.

A most careful and effective method of closing the ends of the cut intestine preliminary to the doing of a lateral anastomosis is provided

by the use of the Payr crushing clamps (Fig. 6.). The intestine is severed with the actual cautery and the ends are burned down flat to the surface of the clamp. Asepsis is thus secured and hemostasis, probably already certain through the crushing force of the clamp, is assured. The cut ends are then easily inverted by the technic pictured in Figs. 7, 8 and 9.

Intestinal Obstruction.—End-to-End Anastomosis.—For most surgeons this method of joining the cut ends remains the method of choice. This is particularly true in cases of *resection for growth or stricture.* I agree with Moynihan[1] that the cleanest and safest way of doing it is the two-row suture method with the aid of clamps. His description of the operation is so comprehensive and illuminating that I take the privilege of presenting it in his own words:

Fig. 6.—The Payr crushing clamp.

"The limits of the gut to be removed being determined, the intestinal clamps are applied. Four pairs are necessary—two pairs at each point of section. If the intestine is at all distended with feculent material or with flatus, the lower clamps can be first applied, the bowel divided, and the upper cut end drawn away from the wound, its clamp removed, and the bowel allowed to drain away its contents into a dish. The upper clamps are then applied and the intestine between them divided. As a rule, however, no emptying of the intestine is necessary, and the clamps both above and below may be applied at once. In placing them in position it is important to remember that they must not be at right angles to the longitudinal axis of the intestine, but that they must lie obliquely, so that their tips approach one another. A triangular portion of mesentery with its portion of bowel is therefore partly included in the grasp of the clamps, the apex of the triangle being toward the root of the mesentery, the base being, of course, the bowel to be removed. By so applying the clamps an adequate blood-supply for the cut ends of the gut is assured, and a slightly larger section of the intestine is left for the anastomosis. The bowel is now divided at each end, and the cut ends at once cleansed with many swabs wrung out of saline solution. As soon as the division is made, each end of the intestine is temporarily wrapped in a swab of gauze and carefully protected so that no soiling of any part of the operation area by contact with a certainly infected mucosa can occur. The incision is carried onward, obliquely into the mesentery, and any bleeding points at once seized with clips.

[1] Moynihan: Abdominal Operations, Philadelphia and London, 1914.

"In this portion to be removed will be the growth, a length of healthy bowel on each side, and a wedge of mesentery containing all the lympathic vessels and glands draining the diseased intestine.

"The approximation of the divided ends by suture is now begun. The clamps are drawn together and laid side by side, and wrapped around with hot moist gauze. If the upper opening of the bowel is rather larger than the lower, as may be the case, a longitudinal incision is made into

FIG. 7.

FIG. 8.

FIG. 9.

FIGS. 7, 8 and 9.—Illustrating the use of the Payr clamp.

the lower portion along a line most distant from the mesenteric attachment. The stitches are now introduced. That portion of the bowel at the mesenteric edge is first stitched, and very especial care is taken with the first few turns of the needle. The first stitch is seromuscular, and picks up the outer covering of the bowel about one-quarter of an inch from the cut edge. The suture begins near the mesenteric attachment, and, in the first two passages of the needle, only the mesentery

is pierced on each side. As the mesentery reaches the intestine its layers separate, leaving a triangular gap. It is the mesentery bounding the triangular gap which is picked up by the first turns of the needle. The suture is then continued, including the serous and muscular coats only (perhaps the submucous, or a part of it, also), until one-half the circumference of the bowel is united, until, that is to say, the part of the gut most distant from the mesentery is reached. The needle is then laid aside.

"The inner suture is now introduced. This includes all the coats of the bowel, and ensures two results—a perfect mechanical approximation of the divided ends of the bowel and hemostasis. It is not necessary to clip and to ligate any points in the cut edges of either end of the intestine. To introduce the stitch skilfully some practice is required. Owing to prolapse or retraction of the mucosa, it may be difficult to pick up, on the needle-point, precisely that amount of intestine which is necessary. The stitch may at first be drawn overtight; it is more likely, however, that it will not be drawn tight enough. I have found the best standard of the necessary degree of tightness that which results from a drag upon the thread from the last stitch of a degree sufficient to raise up, prominently, that part of the walls of the intestine into which the needle is next to pass. If the thread be drawn steadily and held firmly upward, it raises the portion of bowel through which the needle last passed, and makes prominent that part which is about to be caught up in the needle. It is the first two turns of this suture which are of the chiefest importance. By them the gap at the junction of the mesentery and of the bowel is closed, and a perfect serous apposition ensured. As the two openings lie side by side there are two triangular gaps, in the right and left divided ends of the intestine. The stitch is begun by being passed from the mucosa of the lumen of the bowel on the right, through all the wall of the bowel, and through the portion of the mesentery which has just separated from its fellow at the gap; from there the needle passes to the bowel on the left, transfixing all the coats, beginning with the separating layer of mesentery and passing then into the lumen of the bowel; from here it pierces the mucosa about one-eighth inch from the point of its last emergence, through all the coats and through the other leaf of the mesentery; and, finally, it passes from the mesentery to the mucosa of the portion of intestine to the right, entering the lumen of this bowel through the mucosa about one-eighth inch from its original point of entry; the suture is tied and the end left long. The suture is now continued around the posterior half of the margins of the opening, embracing all the coats and being pulled fairly tight and even. No puckering of the gut need be feared. Each individual portion of the stitch must be separately tightened. If one loop be left slack, it cannot be tightened later without releasing all the stitch. The suture approximates first the posterior margins, and then, without change or interruption, is passed along the anterior margins until the end, left long at the first stitch, is reached, when the thread is knotted and cut short. As the

stitch passes along the anterior margin it is important to see that the mucosa is infolded. This may best be done by changing the type of stitch. The needle is passed twice through the bowel on each side from serosa to mucosa and back again to serosa on the one side, then similarly on the opposite side, so that a loop lies always on the mucous surface. As the suture is tightened the mucous membrane is infolded. The last turn of this stitch passes from serosa to mucosa only, and there the knot is tied. The clamps are now removed from the intestine, as the ends are securely closed, in order to see if the suture-line bleeds at all. As a rule, the hemostasis is perfect, but once and again a point will be found to bleed. A separate interrupted stitch is then passed to include this point. The arrest of the hemorrhage being complete, the bowel is again gently washed, and the seromuscular stitch, laid aside for a time, is now restarted. The circuit is completed by carrying this suture along the anterior margins until the mesentery is reached. Two turns of the needle are then taken in the mesentery, and, finally, the needle is passed through the mesentery to the deeper (or posterior) side, where it meets the end originally left long. The two ends are tied and cut short.

"The slit in the mesentery has now to be closed, and the bleeding points in the cut edges to be ligated. It is generally advised that a through-and-through stitch should be used to close the mesenteric wound, but I have found such stitches a source, not infrequently, of trouble. A small vessel may be punctured and a hematoma rapidly forms, or at any point where the needle punctures some hemorrhage may be started. I have, therefore, ceased to use sutures in the mesentery. The plan I adopt is, to tie any bleeding point in the cut edge of the mesentery, and in the same ligature to include subsequently the exactly opposing point in the opposite cut edge. This is done at each point where a clip had been placed, and if the ligatures are not sufficiently close, a clip is introduced on the cut edge of one side, a ligature applied, the clip removed and at once put upon the corresponding point in the opposite edge, which is then taken in the same ligature."

The best single row suture—and it is a most satisfactory one—for end-to-end anastomosis is the so-called "knot-within-the-lumen," Connell suture.[1] The drawings portray the essential steps of the operation far better than any verbal description (Figs. 10, 11, 12, 13 and 14). They show the suture as an interrupted one but it may be and very frequently is applied as a continuous suture with as great safety and equally good results. The only difficulty in laying the suture, either interruptedly or continuously, is tying the final knot so that it will lie within the lumen. Personally, I have grave doubts as to whether it makes the slightest difference whether the knot is within or without the lumen. But Connell lays great stress on that particular feature of his suture and his method of placing it he sets forth as follows:

"Now the two ends of the thread which are to make the knot are

[1] Connell, F. G.: Jour. Am. Med. Assn., 1901, xxxvii, No. 15.

FIG. 10.—Connell suture. Method of applying stitch in mesenteric border. (Kelly and Noble, Gynecology and Abdominal Surgery.)

FIG. 11.—Connell's suture. Knots applied within the lumen of bowel; starting the second row. (Kelly and Noble, Gynecology and Abdominal Surgery.)

FIG. 12.—Connell's suture. Method of inserting needle for tying the last knot. (Kelly and Noble, Gynecology and Abdominal Surgery.)

FIG. 13. — Connell's suture. Thread drawn transversely across, ready for tying. (Kelly and Noble, Gynecology and Abdominal Surgery.)

FIG. 14.—Connell's suture. Latter tied and ready for embedding. (Kelly and Noble, Gynecology and Abdominal Surgery.)

side by side, emerging from the mucosa into the lumen, and then extending from the ununited part of the enterorrhaphy out of the body. The needle, in introducing this stitch, has passed through the cut ends in exactly the same order as it did when inserting the stitches in the earlier part of the operation when the cut ends were held in seroserous apposition—*i. e.*, mucosa, submucosa, muscularis, and serosa, then immediately on into the other cut end through the serosa, muscularis, submucosa, and the mucosa, and then this order repeated in the opposite direction one-eighth of an inch (3 mm.) away.

"The needle and the free end of the suture now hang side by side from the mucosa, and in order that they be tied in a firm knot, proceed as follows:

"At a point in the line of union, about opposite this last and still untied stitch, a threaded needle is inserted, eye first, between two of the previously inserted and tied stitches. The needle is passed between the apposed serous surfaces into the lumen.

"By passing the needle still farther onward it is made to present at the location of the last stitch, where the ends of the suture still protrude, and where the surfaces are not united. By slightly withdrawing the threaded needle a loop is formed with its thread; into this loop are placed the two free ends of the last stitch which is to be tied (Fig. 12.) By withdrawing the needle and in its loop the stitch ends, these ends will be made to present upon the peritoneal aspect of the bowel on the opposite side, between two of the previously inserted and tied stitches —*i. e.*, at the point where the threaded needle was inserted. Slight traction upon these ends will cause the remaining portion of the line of union to become inverted, and seroserous approximation will obtain entirely around the site of suture. Upon greater traction the bowel will become flattened, bringing the mucous membrane upon which the last knot is to be located into intimate relationship with the line of suture at the point where the free ends protrude (Fig. 13.) The knot is tied with the bowel in thus flattened position, thus avoiding the occurrence of any slack (Fig. 14.) While still retaining the tension and the flattened position, the ends of the knot are cut off short, so preventing any long free ends in the lumen. Upon allowing the bowel to assume its normal contour—that of a cylinder—the knot will slip between the already tied stitches into the lumen, and as it is attached to the mucosa of the opposite pole of the diameter of the gut, it goes with that portion of the bowel-wall."

In resection and *end-to-end anastomosis for gangrene and for strangulation and for acute obstruction* with its over-distended, inflamed, infected loop, the technic of laying the suture is exactly the same as that for stricture, etc., but the steps preliminary to beginning the suture are somewhat different and deserve a word. First of all, the surgeon must determine just how much intestine to remove. This is essentially important and it is not always an easy matter to decide. Not only must the intestine itself be carefully inspected but the condition of the mesenteric vessels must be judged. Are the veins extensively throm-

botic? Do the arteries pulsate? Does the peritoneal coat still preserve its color and gloss? Resect too much intestine rather than too little. Give questionable intestine a wide margin especially in a direction proximal to the gangrenous loop. It is not the removal of too much intestine that usually proves fatal but the removal of too little.

In acute obstruction the proximal distended gut must be emptied as a preliminary measure. Again let me quote Moynihan, whose method of accomplishing this is simple and clean:

"The clamps on the lower side of the gangrenous loop are first applied and the bowel is divided between them. The proximal portion of the bowel is then freed from its mesentery to a degree which will permit its being drawn away from the wound for six to eight inches. The clamp which closes its end is then removed, and the gut allowed to empty itself of air and the fluid content. The bowel above the obstruction is emptied by 'milking' until the overdistention is completely relieved. The clamps are then applied above, and the diseased bowel removed."

As far as the mesentery is concerned, in malignant disease a triangular section which contains all the involved glands should be excised with the affected intestinal coil. In most cases of acute obstruction, however, it is not necessary to remove the mesentery to any such extent and sometimes not at all. The free portion left after excision of the intestine may be folded over against the remaining mesentery and be held by a few sutures.

What Length of Small Intestine may be Resected?—How much must remain that adequate nutrition may be maintained? Of late years much experimental as well as statistical work of value has been done in the direction of answering these questions and the results make interesting reading. The problem must always remain one more of academic than of practical interest; for, in almost all cases in which the question of extensive resection arises, whether it be for growth or for a gangrenous process, necessity and not convenience or desirability must determine the limits of resection. Pathological and not physiological facts must serve as our guides. We are usually dealing with conditions which, if left alone, must kill the patient and as a rule our only choice is either to resect the length indicated regardless of its extent or to permit the disease to continue its fatal course.

With this understood, it may be said that at present it seems established that the amount of small intestine which it is permissible to remove depends not on the actual length of the resected portion but on its relative proportion to the whole length of small intestine; in other words, not so much on the amount removed as on the amount left. Probably one-half to two-thirds of the small intestine may be removed without danger of serious consequences in a metabolic way, though as much as 80 per cent. has been resected with recovery.[1] Yet, because of the uncertainty that attends the matter, just as little intestine as

[1] **Flint: Johns Hopkins Hosp. Bull., 1912, xxiii, No. 255.**

possible should be resected. The higher the position of the resected portion, the more serious is the outlook. The prognosis should be guarded, since cases at first apparently successful may die later of inanition. After operation the diet should be poor in fats, relatively rich in carbohydrates and should be of such a character as to be readily assimilated. Most of the patients after operation have some digestive disturbance (diarrhea in particular), which usually gradually disappears. Bismuth with or without salol should be administered.

THE MESENTERY.

The mesentery of the small intestine is a fan-shaped structure and is inserted into the posterior abdominal wall along a line about six inches in length, extending from the left side to the second lumbar vertebra to and occasionally beyond the right sacro-iliac synchondrosis. The distance between the fixed and the free border varies at different levels; at the very beginning it is relatively insignificant, high up in the course of the intestine it measures five to six inches, near its mid-point eight to ten inches, while at the most distal portion of the ileum, it is not more than one inch to one inch and a half wide. Its thickness decreases from above downward and from behind forward. It contains much more fat in the lower than in the upper portion and consequently in its upper part it is correspondingly more translucent. Little transparent spaces, called by Monks "lunettes," are almost constantly present in the mesentery opposite the first eight feet of the jejunum and may serve to identify that portion of the intestine.

CONGENITAL DISPLACEMENTS AND ABNORMALITIES.

But few of these are of practical significance and none can be diagnosed clinically except possibly by the aid of the roentgen rays. Various degrees of a persistent common mesentery may exist in combination with various degrees of faulty decussation of the large and small intestine. This fact has practical importance; for, because of it, the appendix may be found anywhere in the normal course of the large intestine. De Quervain points out, too, that, if the usual decussation has not taken place, in performing a gastro-enterostomy search for the beginning of the jejunum in the usual place will be in vain and it can be found only by following down the course of the duodenum. In cases where the large intestine is on the left, the beginning of the jejunum will be in the vicinity of the right side of the pelvis.

A mesentery of excessive length may lead to an intussusception.

Another sort of congenital defect is found in the lower ileum between the terminal branches of the mesenteric artery. These surround spaces entirely free from bloodvessels, fat or nodes. The defect varies in degree from a well-marked, complete slit or opening to one partly or completely covered by a thin or cribriform membrane. The opening

may be as much as one inch in diameter. The practical bearing of this defect is the occasional strangulation in it of a loop of small intestine. Of course, diagnosis is possible only through operation.

The mesentery like the intestine is open to *injury through a blunt force or a penetrating agent* and the injury may occur in conjunction with or independent of intestinal injury. The matter has already been treated. It is worthy of notice that in rupture of the mesentery the mortality in cases operated upon is about 38 per cent., while practically all the unoperated cases die.

THROMBOSIS AND EMBOLISM OF THE MESENTERIC VESSELS.

While these are uncommon conditions, they occur with sufficient frequency to deserve consideration in all obscure abdominal crises. Though occasional cases occurring in the young have been reported, it is usually in males after middle life that the condition is found.

Embolism is usually secondary and commonly originates in an acute or chronic endocarditis. Thrombosis is sometimes the direct result of a infective process especially in the appendix or the pelvic organs but it is usually secondary to some hepatic condition causing portal stasis; arteriosclerosis of the mesenteric vessels themselves is an occasional cause. Trauma, blunt force or rough taxis in attempted reduction of a hernia, may injure the mesenteric vessels and cause occlusion.

The occlusion involves the arteries in 53 per cent. of the cases, the veins in 41 per cent. and both the arteries and the veins in 6 per cent.[1] The superior vessels are far more commonly affected than the inferior. An artery may be blocked by either a thrombus or an embolus but it is always a thrombus that blocks a vein. In two cases out of three there results a bloody infarction of the intestine with a dark red, edematous lusterless intestinal wall. Rarely an anemic infarction is found. Thus there may occur sloughing of a part of the intestine or a very limited gangrene with ulcer formation and possible perforation.

Symptoms.—There is no clinical method of deciding whether the arteries or veins are occluded and such distinction is not clinically important. Very rarely occlusion takes place so slowly that a collateral circulation may be established and no serious effects will be noted; of course, diagnosis of this condition is impossible. However, practically all cases have a very acute onset and the symptoms, variable and never entirely pathognomonic of the condition, may either (1) simulate an acute intestinal obstruction or (2) exhibit predominantly the signs of intestinal hemorrhage.[2]

In the obstructive form, the less common of the two, the paroxysmal pain comes suddenly and is excruciating; nausea and vomiting (bloody, if vessels supplying the upper intestine are involved), follow quickly; the constipation is usually absolute, though some gas may be passed

[1] Trotter: Embolism and Thrombosis of the Mesenteric Vessels, Cambridge, 1913.
[2] Noland and Watson: Ann. Surg., 1913, lviii, No. 4.

at first; the early temperature is subnormal; the pulse-rate is increased; the abdomen is distended, rigid and tender and the symptoms in general are those of a peritonitis.

In the hemorrhagic form, too, the onset is sudden and the colicky pain severe; pain in the back is not uncommon; nausea and vomiting are present; but, instead of obstipation, one sees frequent bloody bowel movements; prostration is marked early in the attack and is evidenced by the fall of temperature and the rapid pulse; the abdominal distention and other signs of paresis of the bowel are not so well marked as in the obstructive form but this is true only in the early stages; before many hours, signs of free fluid in the peritoneal cavity and of peritoneal infection appear. It is only in rare instances that the thickened, edematous mesentery can be palpated.

Both acute forms are very dangerous and run a rapidly fatal course, especially when considerable length of intestine is involved.

Diagnosis.—The diagnosis is usually not made before operation because the symptoms are not strongly characteristic. This is particularly true of the obstructive form. A careful examination of the cardiac region for valvular disease, a search for signs of atheroma in palpable bloodvessels, knowledge of a preëxisting septic process in the abdomen or the occurrence of emboli elsewhere may rouse our suspicions of the possibility of occlusion of the mesenteric vessels. However, the abdominal symptoms are so alarming and demand operation so urgently that an absolutely definite diagnosis is not necessary. Once the abdomen is opened, the appearance of the dark red, engorged, lusterless and sometimes gangrenous coils make diagnosis certain. The mesentery itself is edematous, the glands enlarged; the veins, when affected, are thickened and rope-like and the arteries without pulsation.

The *differential diagnosis* is difficult, uncertain and in a way unnecessary. At best, only a probable diagnosis can be reached and that usually by exclusion. The average case probably resembles intussusception more than any other acute abdominal condition. Intussusception, however, usually occurs in the young; occlusion of the mesenteric vessels comes in men of forty-five years or more who often show other evidences of cardiac or vascular disease; as an early sign, a distended abdomen is common in occlusion but rare in intussusception; the bleeding is more profuse in the former.

Other acute abdominal crises from which it must be distinguished are perforation of a gastric or duodenal ulcer, acute cholecystitis or appendicitis, acute pancreatitis and acute intestinal obstruction from other causes.

Prognosis.—The mortality at present is appalling. Ingebrigtsen's[1] statistics, which are the latest I have at hand, show a mortality of over 80 per cent. in the 91 cases to which operative measures were applied. Even with early operation, we can expect, I believe, only

[1] Abstract, Jour. Am. Med. Assn., 1915, lxiv, 1282.

occasional recoveries. On the other hand, the mortality in unoperated acute cases must be 100 per cent.

Treatment.—Operation offers the only hope and even that but little. If there is a well marked line of demarcation (said to be present in three-fifths of the cases), resection and lateral anastomosis is the operation of choice; resect well above the gangrenous area. In desperate cases, rapid resection without any attempt at anastomosis may be tried. Both cut ends should be left open on the abdominal wall.

Arteriosclerosis.—Arteriosclerosis of the mesenteric vessels (*Angina Sclerotica Abdominis*) is seen, as a rule, in syphilitics, in alcoholics, in those who habitually use tobacco to excess, and in individuals past forty-five or fifty who have a general arteriosclerosis. The chief symptoms are severe pain located about (particularly above) the umbilicus and meteorism. The onset is sudden and usually follows considerable muscular exertion or mental worry. Nausea, vomiting (sometimes of blood), abdominal distention, alternating diarrhea (sometimes with bloody stools), and constipation are other symptoms. The pulse-rate often keeps about normal. The blood-pressure is usually elevated to a considerable degree. The pain resembles that of angina pectoris and is often accompanied by profuse sweating and by belching and flatulence. The duration of the attack is short, as a rule, and a patient may have several in one day. The attacks sometimes occur at night. The diagnosis is difficult, because the symptoms are frequently severe and simulate those of acute perforation, etc. The age of the individual and the presence of signs of arteriosclerosis elsewhere may give a clue to the cause. The fact that the attacks are relieved by such drugs as the nitrites, trinitrin, etc., may also aid in a diagnostic way.

DISEASES OF THE MESENTERIC GLANDS.

Mesenteric glands may show a carcinomatous or sarcomatous infection secondary to an original process in the intestine and rarely may be the starting point of a primary malignant process. What surgical interest they possess in this regard has already been discussed. These glands may be also affected as part of a general process (Hodgkin's disease, tuberculosis, syphilis). The diagnosis in such an event will be made by observation of the condition of the glands in regions more accessible to examination and by other evidences of the general process. The involvement of the mesenteric glands in Hodgkin's disease is late and, when it comes, the patient is usually in a serious condition with evident signs of the disease elsewhere. Treatment will be without avail. In tuberculosis, too, the general process may involve the mesenteric glands or they may be infected through local lesions in the intestinal canal. These conditions, however, are not of particular interest to the surgeon except as has already been indicated.

A primary tuberculosis of the mesenteric glands is now recognized as a clinical entity and is of particular surgical importance since it

simulates and is almost always mistaken for acute inflammatory conditions, usually appendicitis in the right lower quadrant. Occasionally infected glands or groups of glands may occur elsewhere in the mesentery and the tumor and tenderness may be found even to the left of the umbilicus but the trouble is most commonly found in the ileocecal region.

Children and young adults are the most frequent subjects and the disease occurs quite independently of any family history of tuberculosis.

Symptoms and Diagnosis.—The condition may exist without giving any subjective signs of its presence and be discovered at operation for some intercurrent trouble.

Occasionally, palpable masses of glands may be present and yet give no subjective signs. Trivial, meaningless symptoms, indefinite right-sided pain and soreness with or without digestive disturbance, may be seen in boys not quite up to par who tire easily. Physical examination of these subjects may or may not show palpable glands in the ileocecal region.

But by far the most common set of symptoms are those which are usually not to be distinguished clinically from acute appendicitis. Pain, coming on rather gradually or even suddenly and commonly confined to the right lower quadrant, nausea and vomiting, localized tenderness and muscular resistance, elevated temperature (99° to 101°), quickened pulse and a leukocytosis make up a symptom-complex that cannot be differentiated from appendicitis.

If the process has caused an inflammation of the mesenteric leaves, a loop of small intestine may become adherent and kinked; in that event, obstructive symptoms will dominate the picture.

Risley[1] asserts that if a child or young adult is pale and "sickly" and has had more or less localized right-sided abdominal pain with a low fever, a low leukocytosis and palpable glands, the diagnosis of tuberculous mesenteric noditis is warranted. But, "in the absence of palpable glands and with an acute onset with high fever and white count, the condition is naturally diagnosed as appendicitis."

Treatment.—Of course, in the absence of acute symptoms, even were the probable diagnosis made, operation is not advisable. The usual hygienic measures are indicated and will undoubtedly prove efficient in most instances.

It is the acute case that is always mistaken for appendicitis and no harm results since both conditions require operation. The only question is how far to carry the operation. Shall we dissect out the glands or not? Homer Gage[2] always excises them. Risley is not so radical and does not remove them "unless there are definite indications either from adhesions, ulceration or size of the mass producing pain or mechanical obstruction." I am certain from my own experience that many cases get entirely well, if the glands are left *in situ*. I have excised them in some cases and left them in others. I am usually

[1] Boston Med. and Surg. Jour., 1915, clxxii, No. 7.
[2] Ibid., clxxiii, No. 9.

guided by the size of the mass and the chance of harm to the intestinal circulation, if removal of the mass is in question. Occasionally, resection of a section of intestine is necessary. Whether cases are operated on or not, antituberculous hygienic measures should be insisted upon.

It is only fair to note that Hawes[1] believes that the treatment should always be hygienic with the use of tuberculin.

The presence of such pronounced symptoms as diarrhea, night-sweats, irregular temperature, etc., is a contra-indication to operation, since it is probable that there are other tuberculous foci elsewhere in the body.

MESENTERIC TUMORS.

Solid Tumors.—Tumors really originating in the mesentery are almost always cystic. The so-called solid tumors of the mesentery may be benign (lipoma (most common), myxoma and fibroma), or malignant (sarcoma) but they originate almost always somewhere in the retroperitoneal space and become mesenteric only through their progressive growth. They may attain an astonishingly huge size. Genuine mesenteric solid tumors are very rare.

Diagnosis.—The symptoms are not characteristic in any way. A patient who has had indefinite, meaningless, abdominal symptoms for some time may quite suddenly be conscious of a slowly growing abdominal tumor, usually situated to one side of the medium line, solid or semifluctuant and at first showing a somewhat small degree of lateral mobility. As the tumor grows, the patient becomes emaciated, has increasing difficulty in breathing and develops digestive symptoms but shows no characteristic picture. Periodic attacks of constipation are common, and evidences of pressure upon the deep circulation are often seen. As the growth increases in size, its mobility practically disappears. The small intestine may be pushed anywhere in the abdominal cavity by the growth and the percussion signs (areas of tympany and dulness, etc.), vary with the position of the small intestine and the relation of the growth to the colon.

The lipomata attain the largest size; sarcomata grow more rapidly but usually do not equal the former in size; the sarcomata are not often movable and are likely to be harder and more lobulated than the lipomata; at least early in their growth, they are encapsulated. Emaciation and wasting are naturally more marked with the malignant tumors. Even the benign tumors have a marked tendency to malignant degeneration. Gumma and ganglioma of the mesentery have been observed but are very rare.

A definite diagnosis is seldom possible. Occasionally it may be reached by exclusion. Insufflation of the colon and stomach may help in a diagnostic way. Diagnosis is really not important since all the conditions with which it may be confused are surgical and demand surgical interference.

[1] Int. Med. Jour., 1914, xxi, 1046.

Prognosis.—Except in the fibromata, the prognosis is not good even with operation. Even the benign lipomata, while they do not metastasize, often recur locally. The sarcomata show widespread metastases, especially in the late stages.

Treatment.—The treatment is excision, which in growths of large size is far from easy and sometimes impossible. It is unfortunate that these growths usually exist a considerable time and attain good size before they cause notable symptoms, because early operation would give far better results than are obtained at present. Excision of the large growths is dangerous not only because of the danger of injury to the intestine and mesenteric vessels but also on account of the cardiac collapse which may come on during or shortly after operation (König). A kidney atrophied by the pressure of the growth, a section of the intestine, the vascular supply of which has been compromised or even a portion of the vena cava may have to be removed with the tumor. The best method of approach is from the front (transperitoneally). In hopeless cases Coley's toxins or the roentgen rays may be tried.

Cystic Tumors.—These are far more common than the solid and are usually benign, though an occasional tuberculous or malignant cyst is reported. They may be chylous (most frequent), hemorrhagic, serous, hydatid or dermoid. They are seen more frequently in women and the subjects are usually young (under twenty). They vary in size from that of an orange to that of a large cocoanut, are usually round and may or may not feel fluctuant.

Symptoms.—The cystic tumors give no characteristic subjective symptoms and may exist for years without giving any sign of their presence. In fact, it is usually only through their mechanical action on the intestine that they first declare themselves subjectively. Intestinal obstruction (due to flattening of the coil by pressure of the growth or kinking), volvulus and rarely intussusception are known sequences and bring their own peculiar train of symptoms. In my experience, attacks of colicky pain and partial obstruction of the bowels with intervals of freedom from symptoms have been the usual manifestations of the growths. The pain and obstructive symptoms become more frequent and more persistent, the free intervals become shorter and finally nausea and vomiting, flatulency and other expressions of digestive disturbances have a more or less constant place in the picture. Occasionally the growths press on the common duct and give rise to jaundice. Trauma may cause a sudden, rapid increase (due to intracystic hemorrhage), in the size of the tumor with symptoms of internal concealed hemorrhage. The uncommon malignant type is accompanied by the usual wasting and cachexia.

But the most striking signs of these growths are the physical. No other abdominal tumor possesses so great a degree of mobility especially in a lateral direction. When small and situated in the mesentery of the jejuno-ileum, they lie in the neighborhood of the umbilicus (most often to the right and a little below it), may protrude the anterior abdominal wall and can be moved about very freely. As they increase in size

or become adherent, their range of motion is much restricted. Cysts of the mesentery of the large bowel are usually situated on either side in the course of the colon and are less freely movable.

Diagnosis.—This is frequently impossible except by exclusion. If it can be determined that the tumor is separable from the solid intra-abdominal organs, a long step in the way of diagnosis by exclusion has been made. König regards the demonstration of the presence of bowel over the tumor as an important diagnostic point in connection with the free mobility of the tumor itself. Royster wisely notes that it is difficult to bear in mind in any given case the possibility of mesenteric growth. Relatively few men meet them and, as a consequence, relatively few ever think of them.

In children, a cyst in a fairly high central position is a mesenteric cyst (Makins).

Differential Diagnosis.—*Ovarian Cysts. Uterine Growths.*—By examination in the Trendelenburg or in the knee-chest position, the connection of these growths with the pelvic organs may often be demonstrated as well as the lack of connection on the part of the mesenteric growths; the latter are far more freely movable, especially when fairly small. The differential diagnosis is difficult.

Pancreatic Cyst.—The tumor is usually in a higher situation in the abdomen, is much less freely movable and lies behind the inflated stomach and colon. Digestive symptoms are usually more marked. Examination of the urine may show glycosuria and of the stools, signs of disturbed pancreatic digestion (fatty stools, etc.).

Renal Tumors and Displacements.—These usually retain the kidney-shape and are located well out behind the colon. Their mobility is limited. The history and urinary examination should make the diagnosis of renal tumors fairly easy. A catheter passed into the renal pelvis and retained there while a skiagraphic plate is taken may be of diagnostic help.

Retroperitoneal (Cold) Abscess.—Careful examination of the spine and an skiagraphic plate should indicate much in the way of diagnosis. The rise of temperature should also be of aid.

Tumors of the Omentum.—Very rare and usually adherent to the anterior abdominal wall (Eisendrath). The diagnosis is never made before operation.

Retroperitoneal Growths.—Usually far less freely movable; diagnosis may be impossible.

In fact, it may be said that only through operation can a definite early diagnosis be made in the vast majority of cases. The presence of a suspicious tumor is sufficient warrant for operation to determine its exact location and true character.

Treatment.—The only treatment is operative. Whether to excise the growth with or without resection of the intestine or whether to incise and drain it is often difficult to decide. Occasionally it is perfectly evident that the growth may be safely enucleated, and then, of course, enucleation is the operation of choice. If enucleation without

compromising the viability of the intestine is doubtful, incision of the cyst and drainage, I believe, is the operation of choice, unless the growth be malignant or tuberculous or a benign one which, by its size or location, is encroaching upon the bowel; under the latter conditions, resection of bowel is necessary. Yet, avoid resection when possible, for the mortality accompanying it is over 40 per cent., while that of drainage is only about 6 per cent. If enucleation is attempted, be careful to avoid injuring the mesenteric vessels. The fistula resulting from the drainage usually heals in from one to three months.

APPENDICITIS.

By JOHN FAIRBAIRN BINNIE, M.D., F.A.C.S.

Classification.—The pathological anatomist after examining many diseased vermiform appendices can easily classify them according to the lesions which are present. Such a classification may be useful for the purposes of a museum but is nearly useless for those of the clinician. In a patient what is chronic appendicitis granulosa today may become acute perforative appendicitis tomorrow or a simple catarrhal appendicitis may within a few hours become gangrenous. While acute appendicitis may and often does arise *de novo*, it most commonly affects an organ already the seat of chronic inflammatory changes, the acute attack being an incident, often a fatal incident, in the course of a disease which may have existed unsuspected even for years. For these, among other reasons, no strict anatomical classification can be of much practical value when one is confronted by a patient suffering from appendicitis. In individual instances one may with reasonable assurance judge from the symptoms that the disease belongs to a certain anatomical class but even then, operation may show that judgment to be erroneous while in very many cases the symptoms give little or no indication as to the condition of the appendix beyond the fact that it is inflamed. For our purposes we may adopt Deaver's classification of acute and chronic appendicitis: "The acute form embraces those varieties of inflammation of the appendix usually described clinically as simple catarrhal, ulcerative, perforative, fulminating or gangrenous, and which, upon examination of the excised appendix, reveal acute catarrhal or interstitial inflammatory alterations, ulceration with or without perforation, or partial or complete gangrene. These terms represent in great part only differences in the degree and extent of the local inflammatory phenomena, differences between which it is impossible in all instances clinically to draw a distinction. The chronic form of appendicitis includes those varieties described clinically as subacute, chronic, relapsing and recurrent, and which, upon examination of the extirpated appendix, reveal chronic catarrhal and interstitial inflammatory alterations, with or without ulceration, progressing in rare instances to obliteration of the lumen of the organ, obliterative appendicitis."

Nerve Supply of the Appendix.—Before discussing the symptomatology of appendicitis it is absolutely necessary to consider the relations existing between the nerve supply of the appendix and that of the cerebrospinal system.

The nerves of the appendix like those of other parts of the intestinal tract pass up into the solar plexus. The solar plexus is a congeries of nerve filaments and ganglia coming from most of the abdominal viscera. It is situated behind the stomach and in front of the aorta and pillars of the diaphragm. The central connections of the solar plexus are the large splanchnic nerves and some branches of the pneumogastric. The large splanchnic nerves arise from the chains of thoracic ganglia (fifth or sixth to ninth or tenth inclusive), which lie anteriorly on each side of the vertebral column. These ganglia besides being united in a chain are connected by both white and gray filaments with the anterior primary divisions of the spinal nerves. Stimuli arising from the appendix pass up the nerves accompanying the superior mesenteric artery and enter the solar plexus. After leaving the plexus some of the stimuli take the pneumogastric route, others traverse the splanchnic nerves to reach their receptors.

The receptors of the sympathetic nervous system have certain duties to perform. When proper stimuli are received corresponding messages are sent out to initiate required functions, *e. g.*, to non-striated muscle starting peristalsis, to glands producing secretion, etc. The receptors carry out these duties automatically and under ordinary circumstances there is no consciousness of what is going on. The receptors are unable to translate the stimuli into terms of pain. If however, the stimuli are excessive in quantity or quality they may and do radiate from the sympathetic and thus may readily act upon neighboring spinal nerve centers in the cord.

In Fig. 15 a stimulus adequate to produce pain, arising in the appendix passes through the superior mesenteric to the pre-aortic plexuses reaches the spinal cord and there radiates from its own nerve cell to other neighboring cells (*F*, Fig. 15) and stimulates them. Thus a sensory nerve being irritated pain arises but the brain accepts the messages as coming from the peripheral distribution of the nerve (*S.N.*, Fig. 15) and hence appreciates the pain as being situated at a point which may be remote from the point of origin of the stimuli. Thus stimuli arising in the vermiform appendix may and do occasion pain which is generally referred to the neighborhood of McBurney's point and on operation one may find the *fons et origo mali* at some distance from the seat of pain and tenderness. Visceral pain is of the nature of a viscero-sensory reflex.

In the same manner stimuli may act on a motor nerve (*M.N.*, Fig. 15) and cause contraction of the voluntary muscle which it supplies (viscero-motor reflex). The stimulation of any individual bundle of nerve fibers as it leaves the cord to go to one of the flat abdominal muscles causes contraction of the individual muscle fibers supplied by it and not of the whole muscle.

The muscular contraction which results from a visceral stimulus may remain for an indefinite period and cause a tumor-like swelling. In cases of appendicitis where the examiner believes that he can palpate the appendix it is usually such contracted muscular fibers which he

feels and as there is also present hyperalgesia of the muscle the patient complains of pain, and thus tenderness of the vermiform appendix is erroneously believed to be present. Undoubtedly many of the so-called phantom tumors of the abdomen are of this origin. Mackenzie believes that visceral stimuli can render abnormally excitable, limited areas in the spinal cord and that the functions of the organs supplied

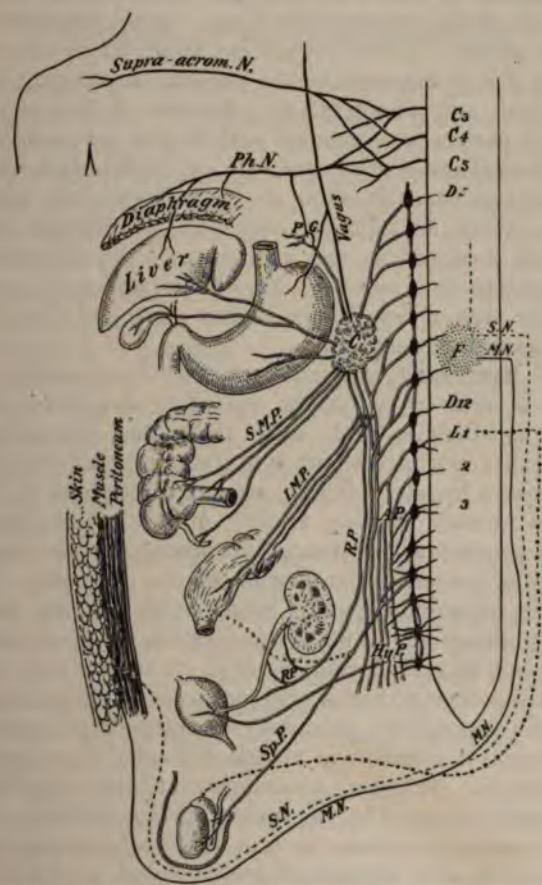


FIG. 15.—*Ph.N.*, phrenic nerve; *P.G.*, phrenic ganglion; *C*, celiac or solar plexus; *S.M.P.*, superior mesenteric plexus; *I.M.P.*, inferior mesenteric plexus; *R.P.*, renal plexus; *A.P.*, aortic plexus; *Hy.P.*, hypogastric plexus; *Sp.P.*, spermatic plexus; *C.*, cervical nerve roots; *D.*, dorsal nerve roots; *S.N.*, sensory nerves; *M.N.*, motor nerve; *F.*, area of stimulation in cord.

by this region are exalted. This explains the hyperalgesia present in appendicitis, gastric ulcer, cholelithiasis, etc.

As the solar plexus forms a sort of pool through which nerves from various parts of the gastro-intestinal tract pass on their way centralwards it would not be surprising should errors in transmission of stimuli take place especially when their number has become exag-

gerated and we find that such errors do apparently arise, which may explain, at least in part, the gastric symptoms often predominant in chronic appendicitis. Mackenzie has observed that the stimuli from excess peristalsis uniformly give rise to referred pain in the middle line.

It has been stated that the sympathetic receptors are unable to appreciate stimuli as pain and that pain from appendicitis and such like lesions are of the viscero-reflex type. There are apparent exceptions to the above. If the vermiform appendix is situated behind the cecum or if it is adherent to the parietal peritoneum it is easy to understand how an inflammatory affection of the appendix may spread to the parietal peritoneum and to the subperitoneal tissues. The subperitoneal connective tissue is richly supplied with cerebrospinal nerves and hence is often the seat of exquisite pain. In the same fashion when an inflamed appendix is adherent close to the trunk of such a nerve as the genitocrural, the inflammation may directly stimulate the nerve giving the sensation of pain which is referred to the area of distribution of the nerve and thus appendicitis may be mistaken for renal colic.

Prodromal Symptoms.—A frank attack of appendicitis may be preceded by a series of symptoms consisting of malaise, indigestion, constipation or diarrhea and vague abdominal discomfort. It has been shown that the prodromal symptoms of gall-stones on which, the older writers loved to dilate, are not prodromal at all but are symptoms of already existing trouble in the gall-bladder, similarly the so-called prodromal symptoms of appendicitis are usually, if not always, signs of present inflammation of the appendix. Frequently an apparently innocent appendix removed during the course of an abdominal operation for other disease, shows on microscopic examination a deposit of granulation tissue in its submucous tunic. Subsequent inquiries elicit no history of symptoms which can be attributed to this chronic appendicitis granulosa except perhaps some occasional vague abdominal discomfort or a little difficulty in regulation of the bowel movements. It is easy to understand how a capillary, whose walls are poorly supported by the surrounding granulation tissue, may rupture and cause a hematoma to form in the submucosa and how this hematoma may readily become infected through an infraction of the mucosa or even without any infraction. The slight infective lesion is well calculated to set up slight and vague symptoms which may be dubbed prodromal, acute symptoms supervening as the infection spreads and especially as it reaches the peritoneum.

The cecal outlet of the appendix may be congenitally narrow or may be contracted by scar-tissue formed in the course of a previous acute chronic infection. The lumen is sufficient to permit efficient evacuation of the appendix under normal circumstances. If, however, a trivial catarrh of the gut is present, the mucosa becomes swollen, the already narrowed lumen becomes obstructed, and the efforts of the appendix to expel its contents give rise to symptoms which when slight may be

classed as prodromal, when more severe, as appendicular colic. If evacuation of the contents is thoroughly accomplished recovery is prompt, if it is not accomplished the infection usually passes from the mucosa to the other tunics and an interstitial appendicitis is present. Here, once more, the so-called prodromal symptoms are really early symptoms of the disease itself.

SYMPTOMS OF ACUTE APPENDICITIS.

Whether so-called prodromal symptoms have or have not manifested themselves the diagnosis of acute appendicitis is based on a series of well-defined symptoms which usually follow each other in a fixed order.

1. **Primary Pain.**—Pain, usually cramping or colicky in character is complained of in the epigastrium or about the umbilicus. This pain usually begins rather suddenly, increases and comes in irregular waves. It is of the same character as that which so often punishes boys for stealing unripe fruit. There may be no tenderness on pressure and no muscular rigidity. The pain usually is most intense about four hours after its onset and then slowly subsides. Sudden early relief from pain may be due to the appendix evacuating its contents into the cecum or to the incidence of gangrene.

2. **Primary Nausea or Vomiting.**—Primary nausea or vomiting usually appears within a few hours of the onset of the attack. It is generally evanescent and must not be confused with secondary vomiting which is due to peritonitis.

3. **Secondary Pain and Tenderness.**—This pain may be colicky but is more apt to be steady and while at first widely distributed over the abdomen, soon becomes localized. The classical site for its localization is in the ileocecal region at McBurney's point, *i. e.*, a point "between an inch and a half and two inches from the anterior-superior spinous process of the ilium in a straight line drawn from that process to the umbilicus." Tenderness on pressure is one of the most important symptoms and may be elicited usually at or near McBurney's point even when there is little or no localized spontaneous pain. Accompanying the tenderness, and of as much importance, there is localized rigidity of the flat muscles of the abdomen.

4. **Fever.**—In from two to twenty-four hours after the onset of the pain there is always some elevation of temperature. In slight cases the fever may be so low and so evanescent that it may not be noted; in severe cases it usually soon reaches 102° to 103°. The pulse is commonly accelerated in proportion to the elevation of temperature but to this there are many exceptions.

5. **Leukocytosis.**—Leukocytosis will be discussed later.

With regard to the orderly sequence of the symptoms J. B. Murphy writes: "If the nausea and vomiting or temperature precede the pain, I feel certain that the case is not one of appendicitis. Where the temperature alone precedes the pain for a day or even two or three, then I am always fearful that it is typhoid fever with a typhoid

ulcer in the appendix. When sensitiveness has been present for a number of days, and particularly where it is low in the pelvis, I have found the focus other than appendiceal, that is, due to infection of the tube, tuberculous peritonitis, etc."

The posture assumed by the patient is often instructive. He commonly lies on his back with thighs flexed so as to relieve abdominal tension. The respiration is liable to be thoracic and shallow to avoid disturbing the abdomen. The face is often anxious and pinched (Hippocratic face), and the patient fears abdominal palpation.

It is not uninstructive to look for a reason for the occurrence and orderly sequence of these classical symptoms even should so doing occasion some repetition.

From an appendix irritated by beginning inflammation a moderately increased number of stimuli pass along the appendiceal nerves to the solar plexus where they initiate a disturbance. The most common cause of disturbance in the solar plexus is the presence of irritants in the stomach or small intestine and hence the customary motor response is an endeavor to get rid of the irritant by increased peristalsis just as a foreign body in the eye occasions involuntary palpebral spasm, increased lacrimation and an almost irresistible desire to rub the eye. In the stomach the increased peristalsis is associated with pyloric spasm and the consequence is the primary nausea and vomiting.

The exaggerated peristalsis of the gastro-intestinal tract in turn increases the impulses sent up the sympathetic from the stomach and small intestine and these, as explained elsewhere, are translated by their corresponding cord centers into terms of pain and are referred to the epigastric and umbilical regions. As the appendiceal inflammation increases the stimuli passing upward from it become more insistent and push their way through the solar plexus to reach the cord centers which control the appendix itself. The number of stimuli reaching the appendiceal center being now greatly in excess of the capacity of that center there is a radiation of energy to neighboring nerve centers or paths. As it happens these neighboring structures belong to the nerve supply of the abdominal wall of the ileocecal region, hence there is steady pain, tenderness and rigidity in this locality.

The early irritating impulses arising from the appendix not only cause pyloric spasm but also cause closure of the ileocecal valve. The increased peristalsis of the small intestine has thus to work against an obstacle which tends to increase its painfulness. The free passage of intestinal contents being hindered by the closure of the ileocecal valve they are prone to decompose and occasion gaseous distention. Valvular closure also explains why constipation is so common in appendicitis in spite of increased peristalsis. One or more bowel movements are common early in an attack of appendicitis but they are usually merely the result of emptying of the large intestine.

The fact that tenderness may be elicited by pressure of the finger introduced into the vagina or rectum when the appendix is situated in the pelvis seems at first glance to contradict the doctrine that

the pain and tenderness are of the referred variety but closer consideration makes one believe that when the inflamed appendix is in the pelvis the inflammation has by contact or continuity passed to the parietal peritoneum and hence to the rich subperitoneal nerve supply. In the same way one may explain the lumbar tenderness found in retrocecal appendicitis. In gangrenous appendicitis when the gangrene is well established, death of the affected parts may stop the supply of nerve stimuli or the toxins may be powerful enough to destroy conductivity and so there may be a complete cessative of pain. In gangrene or perforation sudden relief of tension in the appendix is an important cause of cessation of pain.

The symptom fever arises as soon as toxins are formed and absorbed in sufficient quantity to produce that reaction.

Pain and Tenderness.—The various pains experienced in appendicitis are worthy of very serious study.

Cutaneous Hyperalgesia.—Head and Mackenzie independently drew attention to cutaneous hyperalgesia in visceral disease. Sherren[1] has corroborated and extended the work of Head as it applies to appendicitis. Cutaneous hyperalgesia is tested by gently pinching or stroking the skin, beginning if possible in an area which is not tender and working toward the suspected area. Extreme gentleness is imperative so as to avoid eliciting deep tenderness. Sherren writes: "In appendicitis cutaneous hyperalgesia varies from a complete band extending on the right side from the middle line below the umbilicus in front to the lumbar spines behind, down to a small circular spot a little above the middle point between the umbilicus and the anterior superior spine. This band corresponds to the eleventh dorsal area of Head. Very often the tenderness extends somewhat into the tenth dorsal area also and occasionally, but not often, into the twelfth dorsal area, sending a tongue-shaped process over the gluteal region. The width of the band is in an adult about three inches. This wide area, however, is not the one that is most often present. The usual area is on the right side of the abdomen and of a triangular shape. So often is this triangular area present that I am in the habit of describing it in my notes as the 'appendix triangle' of cutaneous tenderness. The triangle is situated in the right iliac region. Its lower boundary reaches almost to Poupart's ligament, its inner almost to the middle line, and its apex is a little outside the anterior-superior spine, sometimes extending to the midaxillary line."

Superficial hyperalgesia is an early symptom and usually persists until the other symptoms disappear. In recurrent appendicitis, especially where there is stricture of the appendix the hyperalgesia often persists for some time after all other symptoms have disappeared. Head, Sherren, Mansell Moullin all note that disappearance of cutaneous hyperalgesia with persistence of the other symptoms of appendicitis is significant of gangrene or perforation. In a case in which the

[1] Lancet, September 19, 1903.

full band of hyperalgesia is at first present the tenderness may subsequently become limited to the appendix triangle with perhaps a small circular area in the lumbar region. Occasionally the cutaneous tenderness is bilateral—it is never on the left side alone and does not vary with the site of the appendix.

Metzger considers that cutaneous hypoesthesia to a prick is a more valuable symptom than is hyperalgesia to pinching. It is rarely absent in the prececal skin during appendicitis. As a rule, this dysesthesia subsides slowly with the subsidence of the inflammation but persists several days longer than do the other symptoms. Metzger[1] writes: "Convinced that hypoesthesia to a pin-prick at McBurney's point is the rule in inflammatory reactions of the appendix we have inferred that when there is dulling of the perceptive sensibility which determines the abdominal reflex, the reflex itself must be influenced. During the past three years we have systematically studied the reflex in cases of suspected appendicitis and even in the mildest attacks we have frequently found it diminished or abolished. The right abdominal reflex diminishes or disappears during the critical phase but returns with the disappearance of the superficial dysesthesia." Sicard[2] comes to similar conclusions. For the diagnosis of most cases of acute appendicitis the observation of superficial hyperalgesia to pinching and of hypoesthesia to pricking is of more interest than value but like many other little items may be of very great use when the diagnosis is masked. Wilkie[3] puts very great stress on the sudden occurrence of pain usually of a griping character, occasionally intermittent (in fact the classical primary pain), accompanied by tenderness in the right lower abdomen and rectus rigidity but unaccompanied at first by elevation of temperature and acceleration of the pulse. From clinical observation and animal experimentation he draws a sharp distinction between appendicular obstruction and appendicitis. In the latter, inflammation is present from the beginning while in the former it is an end result. If an empty appendix becomes obstructed its own secretions soon distend it with mucopus and this usually in a short time leads to perforation but occasionally the bacteria die off and a mucocele results. If at the time of obstruction the appendix contains an amount of fecal matter an acute, a subacute or a slowly developing empyema forms, its course depending on the nature of the fecal content, both as regards its chemical and bacterial constitution and the consequent reaction which it induces. In very acute cases there are distention of the appendix; (which causes much more sudden and severe pain as a rule than does an inflammation which arises without the preliminary obstructive dilatation), leukocytic infiltration of its wall followed by gangrene, first of the lymphoid tissue and then of the remaining structure of the wall, the whole process, which is of a putrefactive nature, occurring in a space of time to be measured by hours. The whole process may

[1] Bull. Med., 1905, p. 571. [2] La Presse méd., January 11, 1905.
[3] British Med. Jour., December 5, 1914.

run its course with little or no fever. It is only early in the attack that any importance can be placed on this differentiation as in both groups of cases the disease is essentially appendicitis but in the obstructive form perforation and gangrene are more likely to supervene, and that at an early period, before any protective adhesions have had time to form. Furthermore, when perforation does occur the appendicular contents, being under high tension, are more likely to be thoroughly extruded into the peritoneal cavity. In appendicitis beginning without obstruction the symptoms are likely to show themselves in a less brusque form and to be early accompanied by fever. While it is wise to treat the sudden, brusque, severe onset as an indication for promptness in treatment yet one must not lean upon the less sudden and less strenuous symptoms as an excuse for delay because even under these circumstances the gravest dangers may be present.

The incidence of pain more or less remote from the appendix is very well illustrated and analyzed by Mackenzie in a case he reports. In a woman, aged thirty-six years, the abdominal wall over the right iliac fossa was hard and rigid, due to contraction of the muscles. There was no cutaneous hyperalgesia, but pressure on the rigid muscles was very painful. The right thigh was slightly flexed and could be extended only with difficulty, due to a tonic contraction of the psoas. On walking a short distance the patient developed a stoop due to increased contraction of this muscle. When the erector spinæ muscles were lightly grasped those of the right side were found very painful. There were frequent calls to micturition, the quantity of urine passed each time was small but normal in character. On operation the appendix was found red and inflamed, adherent by soft red bands to the cecum and separated from the bladder by coils of healthy intestine.

In this case a viscero-motor reflex caused contraction of the flat abdominal muscles and of the psoas muscle; a viscero-sensory reflex caused increased sensitiveness of the nerves supplying the muscles over the right iliac fossa and the erector spinæ as well as a hyperesthesia of the bladder resulting in frequent micturition. Similar pains and symptoms can be caused by direct extension of the inflammation from the appendix but a similar distribution of the pains would be unlikely under such circumstances. An inflamed appendix lying close to the iliopsoas muscle can directly occasion pain and lameness of that muscle and simulate coxitis; lying close to the urinary bladder it can involve the bladder and cause either increased frequency of urination or retention; lying in contact with the gall-bladder it can produce the symptoms of cholecystitis. These muscular, urinary and biliary symptoms are, of course, not phenomena of appendicitis but of inflammation which has spread from the appendix to otherwise innocent neighbors and illustrate the proverb that "evil communications corrupt good manners."

Pain in the region of the liver and the bile passages is often the result of lesions set up in them by agents brought to them from the appendix through the portal circulation.

Pains which closely simulate those of gastric ulcer will be discussed elsewhere.

Sonnenberg points out that in young women suffering from dysmenorrhea if there are difficulties in urination the physician should suspect the presence of subacute or chronic appendicitis.

Method of Examining for Tenderness, Rigidity and Tumor.—POSTURE.—The patient should lie on his back with the thorax slightly elevated and the thighs slightly flexed and supported by pillows. If the patient keeps his mouth open during the examination the relaxation of abdominal tension secured by posture, is aided. This posture or some modification of it is the one commonly assumed by the patient in his efforts to avoid or lessen pain.

INSPECTION.—With the abdomen well exposed in a good light, note the character of the respiration whether abdominal or thoracic, free or restricted. Observe the presence or absence of abdominal distention and whether such, if present, is localized or general. The presence of visible peristalsis is important as indicating mechanical obstruction.

Examination for Cutaneous Hyperalgesia and Hypoesthesia.—Very *gently* pinch or stroke the skin of the abdomen first over areas where no hyperalgesia is expected and later over the suspected regions. Remember to examine the lumbar region as well as the iliac. Map out the areas of increased sensitiveness. With a pin-point find and map out any areas which show diminution or loss of the normal sensitiveness to a prick (Hypoesthesia). With a pin, lightly scratch or stroke the sides of the abdomen and observe whether the normal abdominal reflex is altered on one side.

The significance of these symptoms has already been discussed. It is well always to examine for the superficial signs before proceeding to the more important method of palpation.

PALPATION.—Lay the warm hand flat on the abdomen, preferably about the epigastrium or on the left side and with infinite gentleness exert finger pressure so as to note any evidence of tenderness. Gradually slide the fingers and hand over the areas where trouble may be expected and examine every part of the abdomen. Even before the patient can complain of pain on pressure involuntary contraction of the abdominal muscles usually tells the story. The examining fingers may find the whole abdomen tender and rigid which indicates spreading or advanced peritonitis or the abdomen may be generally insensitive and relaxed, tenderness and rigidity being confined to certain well-defined localities. While palpating for tenderness or rigidity the fingers also note whether there is any tumor or induration to be felt in the abdomen. Palpation must always be carried out with extreme gentleness—vigorous prodding with the fingers causes much pain, excites such spasms that nothing can be perceived through the board-like muscles and is very liable to produce rupture of a distended, soft appendix or of a delicately segregated collection of pus.

Of the localities in which tenderness is most commonly elicited McBurney's point is the most important. If in the presence of the

other classical symptoms, muscular rigidity can be elicited by gentle pressure at a point about one and a half to two inches from the anterior superior iliac spine on a line connecting that process with the umbilicus, then the diagnosis of appendicitis may be made with great surety. Absence of tenderness in this region, however, must not be taken as proof that appendicitis is not present. Even in the rare cases of transposition of viscera when the cecum and appendix are on the left side pain and tenderness are present at McBurney's point, although they have also been described as occurring on the left side.

Blumberg[1] considers that the best way to elicit tenderness at McBurney's point, especially at a very early period of appendicitis, is to exercise firm pressure slowly and then suddenly to remove the pressure. As the pressure is relieved pain is experienced. Like most of the other refinements in method this is of distinctly less value than the original simple palpation.

Landau finds Blumberg's sign present in other diseases than appendicitis, *e. g.*, in annexitis occurring in patients whose appendix is healthy or has been removed. He also notes that the sign may be absent in appendix dyspepsia, chronic appendicitis, etc.

Lanz's Point.—Lanz's point is sometimes incorrectly referred to as an area of increased tenderness. It is situated at the junction of the middle and right thirds of a line joining the two anterior iliac spines and is from 0.5 to 1.5 cm. internal to the site of the base of the appendix in 87 per cent. of the cases examined.[2] Lanz described this point as a landmark for operation and not for diagnosis.

Hertzler's Point.[3]—Draw one line from the umbilicus to the tubercle (not the anterior-superior spine), on the crest of the ilium. This passes below the right kidney and 5 cm. above the ileocecal junction. Draw another line from the umbilicus to the pubic tubercle (3 or 4 cm. from the median line).

These two lines with Poupart's ligament as a base form an isosceles triangle. If now the three angles of the triangle are bisected the bisecting lines will meet at a point in the middle of the triangle and this point corresponds to the base of the appendix. Hertzler based his conclusions on an examination of 1080 bodies.

The Morris Point.—Robert T. Morris[4] lays great stress on tenderness elicited on deep pressure at a point an inch and a half to the right of the navel. The tenderness is of little or no value in "intensive infective appendicitis" but according to him is of great diagnostic worth in what he calls "protective appendicitis." If tenderness is present both to the right and left of the umbilicus tubal disease may be suspected.

Loeper and Esmonet[5] discuss very fully the significance of tenderness on deep pressure at what they call the para- and subumbilical points which correspond closely to or are identical with the points described

[1] München. med. Wchnschr., June 11, 1907.
[2] Lanz: Centralbl. f. Chir., February 15, 1908.
[3] St. Louis Courier of Med., January, 1904.
[4] Am. Jour. Obst., 1909, No. 5. [5] La Presse méd., April 23, 1910.

by Morris. They attribute the deep hyperesthesia "to two orders of principal causes: Some intestinal, others extra-intestinal or general. It often appears in abdominal diseases when no inflammatory phenomena are present and appears due to simple mechanical troubles" such as ptoses where there is constant dragging on the sympathetic nerves. "In the majority of cases the origin is clearly inflammatory; the altered chemistry of digestion, the fermentations which characterize dyspepsia, cecal stasis, atony consecutive to infectious diseases or to general malnutrition, true enteritis, infected cancers—all these may be the causes of irritation to the centers."

The writer believes that tenderness at or about Morris's point is indicative of various conditions such as visceroptosis, in which some form of chronic appendicitis is so commonly present, rather than of appendicitis itself.

It should not to be forgotten that lymphangitis and adenitis may be present in the root of the mesentery and give rise to pain and tenderness at points even remote from the well-known classical areas of tenderness.

Berard (Berard and Vignard) draws attention to adenitis of a single subcutaneous node near the external inguinal ring. This generally becomes appreciable on the second day and reaches its maximum size in about forty-eight hours. It varies in size from a pea to a cherry; is round, hard, elastic and tender. In cases where the gland is large and the symptoms of appendicitis are slight there is spontaneous pain in the gland.

"When the signs of peritoneal reaction are not marked, the inflammation remaining more or less clearly limited to the appendix, the glandular enlargement reaches its maximum."

If this is true then a much enlarged gland is a rather favorable sign. Once the gland has reached its maximum size it remains stationary during the attack, diminishes on recovery and only leaves for a time a slight tenderness. If the appendicitis recurs the adenitis always recurs also but the gland is never so large as in the first attack.

Vaginal or Rectal.—Vaginal or rectal palpation must never be omitted in cases where the symptoms point toward appendicitis but abdominal palpation gives negative results. A finger in the rectum or vagina may elicit tenderness or demonstrate an inflammatory mass and so clinch the diagnosis. This method of examination is particularly valuable in children.

Rovsing's Sign.—To distinguish inflammation of the appendix from that of neighboring organs Rovsing sought to increase the tension of the intracecal gas by exercising pressure with the hand on the descending colon. It was assumed that the intracecal pressure would cause pain in the appendix. In some cases the method appeared to aid in diagnosis but in others it led to error. Few surgeons place much confidence in it.

If on successive examinations tenderness and rigidity are found to become less localized it is evidence of spreading infection. If in a

patient whose condition has been improving there is a renewal or a sudden access of pain with increase in tenderness and rigidity one may safely infer that the disease has lighted up again or that the giving way of some adhesion has permitted the extension of infective material into fresh regions of the peritoneum. Sudden atrocious pain and shock signify perforation into the free peritoneal cavity but a marked decrease in the pain, tenderness and even in the rigidity may mean the same thing. In judging the significance of these alterations in the local signs the general symptoms are of enormous importance. As noted already a sudden loss of pain, etc., with amelioration of the general symptoms means that a distended appendix has evacuated its contents into the colon and the acuteness of the attack is over at least for a time—while the same signs without amelioration in the general condition are of the gravest import.

The same gentle palpation used for the investigation of tenderness and rigidity shows whether any tumor is present. According to the amount of exudation surrounding the appendix and soaking into the neighboring tissues there will be a feeling of fulness given to the palpating finger; masses of omentum which serve to isolate the focus of inflammation may form a tumor even of large size and almost always signify the presence of periappendicular pus. Even if no tumor may be palpable through the abdominal wall rectal examination may reveal such in the pelvis. In retrocecal appendicitis tumor is often most marked in the loin. Instead of appendicitis, tumor may merely signify a colon overloaded with feces. Percussion carried out over the iliac fossa is of little value. Owen (Appendicitis) writes: "If the note is resonant, it shows that the entire region is not occupied either by abscess or by fecal accumulation. If the note is dull, it shows that inflated bowel is absent. But the information is of no practical value, and the obtaining of it leads to waste of time and to further and perhaps harmful fingering."

Fulness in the iliac region is usually a phenomenon of peritonitis rather than of appendicitis and is a sign that nature is endeavoring to isolate the focus of infection. The most dangerous cases of appendicitis frequently present no tumor or fulness, the disease process is too rapid and virulent to permit of protective reaction.

Nausea and Vomiting.—The primary nausea and vomiting of appendicitis has already been considered. It is usually of short duration and is reflex in character.

Secondary vomiting, which is a much more serious and menacing phenomenon, usually belongs to the digestive disturbances initiated by the closure of the ileocecal valve or by paralysis of the intestinal walls by toxins. After the stomach has emptied itself there is regurgitation into it of grumous and later stercoraceous material. When this material is in turn expelled it often flows out of the mouth without effort, being in fact a regurgitation rather than a vomit. The intestinal stasis is accompanied by decomposition of the gut contents and hence there is gaseous distention. Visible peristalsis so characteristic

of mechanical obstruction of the bowels is notable from its absence. If the intestinal contents are very irritating and intestinal paralysis is absent, diarrhea may be evident instead of the more common constipation.

Hiccough may be present and may be due to the absorption of poisons secreted in the duodenum or to subphrenic involvement.

Hematemesis.—Hematemesis is a rare accompaniment of appendicitis as is also hemorrhage into the intestine. The most reasonable hypothesis regarding its causation seems to be that minute emboli passing from the appendix through the portal veins, are dammed back into the gastric veins where they cause thrombosis.

Payr was able to produce gastric hemorrhages by introducing fine powder into the portal veins. If Payr's views are correct they throw important light on the so-called appendicular dyspepsia which is frequently mistaken for gastric ulcer.

Temperature and Pulse in Appendicitis.—Fever varies much in appendicitis and is not of great value either in diagnosis or prognosis. It may be preceded by a chill. The temperature may be high in the beginning and fall rapidly or it may gradually rise to a maximum in thirty-six to forty-eight hours. In other cases it may be absent even in the presence of a large abscess or of generalized peritonitis. Usually the temperature is not remarkably high—often being not more than 100° F. and rarely over 103°. A simple catarrhal appendicitis may show a fever of 103° or 104°, while in gangrene it may be normal. A continuous high temperature is indicative of severe and spreading infection with general intoxication. When the disease has become well localized the temperature and pulse often become normal and any subsequent increase in them points toward further spread of the disease.

Usually a low temperature with a rapid pulse is of the gravest significance.

A remittent or intermittent fever of the hectic type is indicative of hepatic abscess, phlebitis or pyemia.

Lennander noted that the normal difference between the rectal and axillary temperature is often greatly increased. This difference may be due to the thermometer in the rectum being close to the inflamed structures but it may also be due to collapse producing a marked fall in the surface temperature.

The Pulse.—The pulse is of most importance when viewed in relation to the temperature. In acute appendicitis the pulse is early accelerated and remains slightly so during the active process even although the temperature may not be elevated. In the nervous and children a rapid pulse is the rule even in purely functional disorders. In spreading peritonitis with beginning meteorism the pulse is rapid, full and of high tension. When intoxication is great the pulse becomes very rapid, weak, irregular and the temperature falls to normal or subnormal. A slow pulse of poor quality is a bad prognostic sign but the pulse may remain good even when a fatal issue is imminent.

Chills.—Chills are occasionally present early in appendicitis and usually indicate serious damage to the appendix. Kelly found that 50 per cent. of his cases of diffuse peritonitis had chills either at the onset of the appendicitis or at the beginning of the symptoms of the peritonitis.

Repeated chills are strongly indicative of the infection of new areas or of pyemia.

The General Appearance of Patient.—The general appearance of the patient may be of great value in diagnosis and prognosis but may also be misleading. Every one has seen patients who appeared cheerful and without a trace of suffering and yet were moribund. Usually there are signs of septic intoxication. The cheeks are flushed, the eyes bright, the skin yellowish. There is an anxious expression and

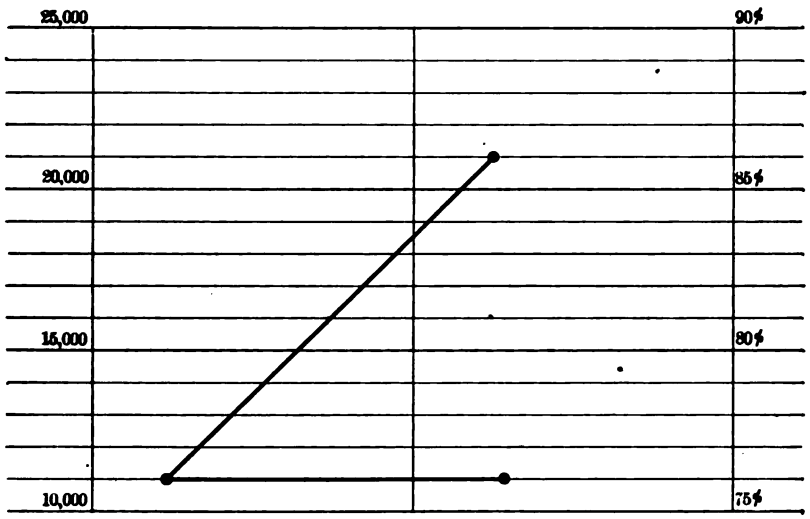


FIG. 16.—Gibson's chart.

the facial muscles are strained. The tongue is coated—at first being moist, later dry. All these are principally symptoms of reaction to intoxication and indicate serious mischief. When perforation or gangrene cause much shock there may be temporary pallor with cold sweats and a pinched expression on the face.

If one finds a patient with a distended abdomen, very rapid and weak pulse, subnormal or even normal temperature, cyanosis, or coldness of the extremities, one may safely presage very early death even although he may have no pain and may look and feel cheerful.

The Blood.—The ordinary leukocyte count has proved of very little value in appendicitis. Sondern[1] suggests that the polynuclear count is an index of infection, the total leukocytosis an index of body reaction and that their proportional relationship is an index of resistance.

[1] Med. Record., lxvii, 452.

C. L. Gibson[1] finds that 'in inflammations which are well resisted, the polynuclear cells are increased approximately one degree for every 1000 of the total leukocytosis above 10,000.' In Fig. 16 (Chart 3, Gibson's article), a dot on the left indicates a leukocyte count of 11,000, dot on the right shows 76 per cent. of polynuclear cells; a line joining these two dots is horizontal and shows a proper proportion between the two elements of the count and a mild or well-cared-for infection. If, however, the polynuclear cells constituted 86 per cent. of the total leukocytosis the line connecting the two dots would be very steep from left to right and there would be a ten unit disproportionate increase of the polynuclear cells—a very menacing condition.

L. B. Wilson[2] corroborates Gibson's findings. He considers that the value of Sondern's "resistance line" is of little value to the surgeon in early cases as most of these are operated on anyway but that in cases between the fourth and the fourteenth days "it is of great value to the surgeon in indicating the patient's poor resistance and the necessity for immediate operation."

Sonnenburg is an enthusiastic advocate of the value of a similar differential count which he attributes to Arneth.

The Urine.—The urine presents nothing of interest in appendicitis except that it may contain albumen and casts as a result of toxic nephritis.

Summary.—So much space has been taken up with a discussion of the symptoms and especially the subordinate symptoms of appendicitis that a condensed review or summary of the subject is necessary.

A. Symptoms of Acute Appendicitis.—With or without a history of prodromal symptoms there occur:

1. *Primary Pain.*—Primary pain usually referred to the epigastrium or umbilical region. This pain is griping in character, comes on suddenly or more or less gradually and increases in intensity for some hours.

2. *Nausea and Vomiting.*—These appear within a few hours of the onset of pain. The vomit at first consists of the stomach contents and bile. If vomiting continues it becomes grumous, later stercoraceous and is often regurgitant rather than expulsive in type (secondary vomiting).

3. *Secondary Pain.—Tenderness, Rigidity.*—At first the secondary pain is widely distributed over the abdomen but within a few hours it becomes localized in the right iliac region. It is a continuance of the primary pain but is usually more steady in character and its localization is very distinctive. Pressure elicits tenderness, usually most acute at McBurney's point. With the tenderness there is muscular rigidity. Local fulness or later tumor are often notable.

4. *Fever.*—Fever usually appears in from two to twenty-four hours after the initial pain. It may be slight or quickly rise to 102° to 103° F. or higher. The pulse is usually accelerated in proportion to the

[1] Ann. Surg., xliii, 485.
[2] Mayo Clinic, 1905–1909.

temperature. A rapid pulse with a low temperature is usually a sign of danger.

Chills when present signify a grave lesion; if they are repeated spread of infection or pyemia may be inferred.

5. *Leukocytosis.*—Leukocytosis is not of much importance as a symptom. Leukopenia in the presence of grave symptoms means poor resisting power and a bad prognosis.

6. The *facies abdominalis* when present is often a great aid in diagnosis.

While stormy symptoms indicate severe disease, mild symptoms must not be accepted as reliable evidence of the absence of grave danger. Some of the worst cases of appendicitis go on to a fatal issue without flying any urgent storm signals.

B. Symptoms of Subacute Appendicitis.—The symptoms are similar to those of the acute disease but are less severe and may be longer in developing. Subacute appendicitis may become acute or give rise to acute peritonitis without warning and therefore must be treated with as great respect as the acute.

C. Symptoms of Recurrent Appendicitis.—Recurrent appendicitis being merely repeated attacks of the acute or subacute disease requires no special discussion. Between the attacks there may or may not be symptoms of chronic appendicitis.

D. Symptoms of Chronic Appendicitis.—The diagnosis of chronic appendicitis does not lend itself to summarization. It may be extremely easy or exceedingly difficult, if not impossible, without exploration. The classical symptoms are vague abdominal pains with slight tenderness about McBurney's point but this latter is often absent. Constipation is the rule but may be varied by attacks of diarrhea. Complaints of flatulence are frequent and the patient is subject to what are popularly known as "bilious attacks" and "bilious headaches." The appetite is often capricious and indiscretions in diet frequently lead to increase of the symptoms. Especially in women, increased frequency of urination may be so marked as to interfere with social life. Rovsing's sign is sometimes useful in making a diagnosis. Colonic insufflation by means of the rectal tube causing pain in the ileocecal region (Bastedo's sign) is highly thought of by Bastedo and Hertz. Goodman and Lüders[1] agree with Bastedo and Hertz that colonic inflation causes no appendiceal pain in normal individuals but consider that it is useless as a test in chronic and dangerous in acute appendicitis.

The greatest difficulty in diagnosis is presented by cases of appendicular dyspepsia or gastralgia (appendicitis larvata). In these all the symptoms are referred to the stomach and may simulate or even be identical with those of gastric or duodenal ulcer.

Mayo, Moynihan, Soltau Fenwick, H. J. Paterson, Sonnenburg and many others early drew attention to the fact that in many patients

[1] Am. Jour. Med. Sc., September, 1914.

after a definite diagnosis of gastric ulcer no lesion of the stomach could be found on operation but that the removal of a diseased appendix led to cure. In many of the cases the gross anatomical lesions of the appendix were not striking and frequently no history of symptoms suggesting appendicitis could be elicited. Moynihan's description of "appendix dyspepsia" cannot be improved upon. "The symptoms are pain, which comes on soon after food, usually within half an hour to one hour, but sometimes later, sometimes earlier, and usually with caprice. There is here no fixed interval of relief after a meal, as is constantly the case in chronic gastric ulcer. The patient will say that the pain comes "at any time" after a meal. The pain is epigastric; it is rarely felt elsewhere, though it may spread over the abdomen to one or both sides, or, rarely, to the back; pressure often gives great relief to it for the moment. It is always worse on exertion and after exercise; a game of golf, an evening's dance, a day's hard physical work will always excite the pain or increase the severity of that which food has caused. Flatulence, the belching of gas, and sour eructations may all be present, and vomiting is not infrequent. In the vomited matter and in the contents removed from the stomach after a test meal there may be an increased amount of free hydrochloric acid. Epigastric tenderness is sometimes, indeed generally, present, and in two cases of my own was well marked beneath the left costal arch, so that, in both cases, I had been led to diagnose an ulcer on the lesser curvature of the stomach.

"Tenderness is not present in any other part of the abdomen, though it is a frequent experience to find that the patient complains of epigastric discomfort, his "usual pain," he may say, when pressure is made over the appendix. Nausea is not infrequent, and hematemesis may occur. In perhaps a dozen cases of my own the hemorrhage from the stomach has been considerable—that is to say, a quantity in excess of a pint has been vomited at once. In one case I visited the patient at her own home with her medical attendant, and we saw that about three pints of blood had been vomited in twenty-four hours." . . . "After the 'attack' has passed away the patient's health may greatly improve, but there is never the same absolute return to complete unthinking health as is seen in cases of duodenal, and less commonly of gastric, ulcer.

"There is always, I find, epigastric uneasiness, some concern as to the quantity or quality of the foods to be taken, and red meat, especially, seems to be avoided by many patients. The regurgitation of bitter fluids and a burning of the throat are taken to indicate a persistent acrimony of the gastric contents. The exacerbation in the symptoms which is described by the patient as an 'attack' may occur infrequently or at short intervals. Something depends on the nature of the life the sufferer leads, but more upon the care with which food is taken." . . . "Sometimes, though this is quite exceptional, the

[1] British Med. Jour., January 29, 1910.

beginning is made to date from an acute illness, which inquiry may indicate as having been due to appendicitis. In by far the great majority, however, the onset is insidious, its exact beginning unknown, and its earlier developments imperfectly remembered."

Soltau Fenwick[1] found in 112 patients with chronic gastric hypersecretion in whom operation was performed, 22 in which the appendix was at fault.

Sherren[2] thinks that there are two types of appendix dyspepsia: (1) Those in which there is a reflex spasm of the pylorus, as pointed out by Mayo, usually associated with an excess of acid in the test meal but not with any particular type of appendix; (2) those due to obstruction from spasm of the ileocolic valve or from interference with the lower ileum.

Lane, with much truth, classes appendix dyspepsia among the symptoms of intestinal stasis.

Chronic appendicitis is very often not a disease *per se* but merely a concomitant of the conditions present in Lane's syndrome.

DIFFERENTIAL DIAGNOSIS OF APPENDICITIS.

As a rule the diagnosis of appendicitis presents no difficulty, yet most surgeons have had the distressing and humiliating experience of opening the abdomen for non-existent appendicitis and then finding what they should have found before—that the symptoms were due to pneumonia or to renal calculus. While it is true that in many cases of appendicitis the symptoms are so clear that error is almost impossible and the patients are in such critical condition that a thorough general examination is entirely unjustifiable, yet in the majority such an examination ought to be the routine and if made properly will occasionally prevent a catastrophe. The temptation to make a snapshot diagnosis is often great but the danger in so doing is not trivial.

Typhoid Fever.—Typhoid may present the local symptoms of appendicitis but with these the temperature is, as a rule, too high and the pulse too slow. In typhoid there is a history of malaise, headache, epistaxis and usually slight diarrhea. The tongue is early furred and dry. The roseolar eruption should be looked for though it is very evanescent. Widal's reaction is valuable when positive. A history of previous typhoid or of antityphoid inoculations renders the positive reaction of little moment. Leukopenia is characteristic of typhoid but the number of leukocytes may be increased to 12,000 or even 15,000. As Deaver remarks, "Fortunately it is in the earliest stages of typhoid fever that the diagnosis is most difficult, at a period of this disease when a simple laparotomy is well borne, and hence a mistaken diagnosis is not so serious as it becomes during the third or fourth week of the fever."

[1] Lancet, March 12, 1910.
[2] British Jour. Surg., i, 397.

When perforation of a typhoid ulcer takes place it usually does so during the second, third or fourth week of the disease. The diagnosis of typhoid has usually been made long before the acute symptoms might lead to error but history may fail in cases of "walking typhoid." Fortunately differential diagnosis is of comparatively minor importance both in the intestinal perforation and hemorrhage of typhoid, as the best treatment is assuredly operative.

Acute Indigestion.—Under this rather indefinite name may be included gastro-duodenal catarrh, intestinal colic, acute enteritis, etc. In all of them there are usually cramping colicky pains, accompanied by nausea, vomiting and generally, diarrhea. There is commonly a history of injudicious diet or the ingestion of some food not above suspicion as to quality.

While the patient may lie on his back with knees drawn up as is common in appendicitis yet the hand pressing on the abdomen gives relief from the pain and there is no rigidity. While fever may be present in acute indigestion it is much more characteristic of appendicitis. When the stomach and bowels have been well evacuated the symptoms decrease or disappear. In the past so many serious intra-abdominal diseases have been masked by the indiscriminate use of the name "acute indigestion" and of the drug opium that the physician ought to look with suspicion on the domestic diagnosis of stomach-ache and the domestic remedies, castor oil or laudanum and satisfy himself by careful physical examination even at the risk of being thought an alarmist, that no inflammatory lesions are present. The danger from the use of opiates is that the resultant feeling of well-being, masks the pain, tenderness and rigidity which are the great danger signals. Laxatives, while they give almost instantaneous relief in many cases of mild obstructive appendicitis, are most efficient agents for the spread of peritonitis when there are any grave lesions of the appendix, gall-bladder or stomach.

When the intestinal trouble is due to ptomaine poisoning, a history of the ingestion of suspicious food is generally present. If several people have similar symptoms after partaking of the same materials diagnosis becomes easy. The symptoms begin a little indefinitely some hours after the poison has been swallowed. They very soon become distressing. Abdominal pain, vomiting, diarrhea, general depression, etc., are marked. The pain is continuous, the whole abdomen is distended, rigid and perhaps tender. There is no localization of the pain, tenderness and rigidity. The temperature is usually not elevated but may be high late in the attack.

Gastric or Duodenal Ulcer.—In most cases the differential diagnosis between these ulcers and appendicitis is easily made from a study of the history, stomach contents and physical signs but as shown elsewhere the differentiation is sometimes impossible with our present means of investigation.

Intestinal Obstruction.—The pain and shock in obstruction are usually more severe than in appendicitis. Vomiting is severe and per-

sistent in spite of gastric lavage. After the lower gut has emptied itself there is passage neither of feces nor of gas. If intussusception is the cause of the obstruction blood-stained mucus is voided per rectum and a sausage-shaped abdominal tumor is palpable in about half the cases. Rectal examination must never be omitted in any case of obstruction. Visible peristalsis is one of the most valuable signs distinguishing true obstruction from the physiological and paralytic varieties.

In obstruction the temperature is normal or subnormal until peritonitis supervenes.

Mesenteric Thrombosis.—Mesenteric thrombosis when on the right side cannot be distinguished from appendicitis.

Perforating Ulcers of the Cecum and Ascending Colon.—Perforating ulcers of the cecum and ascending colon can only be distinguished from appendicitis at operation. In chronic lesions examination by the *x*-ray after filling the colon with a suspension of bismuth may determine the diagnosis, in acute disease such methods are improper.

Carcinoma of the Colon.—The diagnosis may be made from the history, the character of the tumor and especially by examination of the whole tumor obtained at an operation performed before the incidence of some of the classical signs of carcinoma have made the diagnosis, and at the same time a fatal prognosis, unmistakable.

Tuberculous Peritonitis.—This is occasionally a sequel of tuberculous appendicitis. In diagnosis attention must be paid to the history of the case, to the results of thorough examination of the chest, bones, joints and glands, to investigation of the sputum, urine and feces. Some variety of tuberculin test may be of value. The presence of ascites which is a fairly early occurrence in tuberculous peritonitis aids in the diagnosis. The evening fever and night sweats of the tuberculous are very suggestive.

Spermatic Cord Lesions.—Lesions along the course of the right spermatic cord and in the right inguinal canal have led to error in diagnosis but a moderately careful examination ought to exclude such.

Cholecystitis Either With or Without Gall-stones.—One must not forget that cholecystitis frequently coexists with appendicitis. Each or either of these coexisting inflammations may be acute or chronic. Differentiation between cholecystitis and appendicitis is, as a rule, easy but it may be difficult or even impossible. Gastric and duodenal ulceration, cholecystitis, pancreatitis and appendicitis may present at times almost identical symptoms. In both appendicitis and cholecystitis jaundice may be present but it is more characteristic of the latter.

Acute biliary colic scarcely requires discussion.

Cholecystitis often begins with a hunger-distress which is not even temporarily stopped by food or drink. Later vomiting, more severe and persistent than in appendicitis may be prominent. While acute pain in the right hypochondrium and about the angle of the

right scapula is classical it is often replaced by a feeling as if the liver were so enlarged and heavy as to weigh distressingly on the back or right side when the patient is lying on his back or right side and to drag distressingly when he is lying on his left side. There is tenderness on pressure over the region of the gall-bladder and this tenderness is increased on deep inspiration, especially if the examiner's fingers are somewhat hooked under the ribs. Rigidity of the upper portion of the right rectus is almost invariably present. Chills and high fever are more common in affections of the gall-bladder than of the appendix.

Hepatic Abscess and Subphrenic Abscess.—Both may be complications of appendicitis. The previous history, the hectic temperature of hepatic abscess, the localization of the pain and areas of dulness must be depended on for aid in diagnosis.

Pancreatitis.—During the first two days of acute pancreatitis the pain, tenderness and rigidity are most marked in the upper right quadrant of the abdomen. Occasionally the presence of glycosuria and fatty diarrhea are informing. Often all the diagnosis possible is what Battle has named "the acute abdomen."

Renal Colic.—Under exceptional circumstances renal colic may be confused with appendicitis, especially when the latter has irritated the genitocrural nerve. Usually the intensity of the pain, its origin in the back and its course toward the testicle are characteristic of renal colic.

Examination of the urine especially for blood is of prime importance. One must not forget that a toxic nephritis of appendicular origin may alter the urine or that renal disease may coexist with appendicitis.

Murphy's "fist percussion of the kidney" is a valuable aid in diagnosis. It is carried out as follows: The patient being in the sitting posture bends forward as far as possible; the examiner places his left hand flatly and firmly on the back of the patient over the suspected kidney and then strikes the dorsum of the left hand sharply with his right fist. If an acute congestion, infarction, retention in the pelvis of the kidney or ureteral obstruction exists in that kidney, the patient will cry out with the pain of the blow. If the renal pain is due to a mobile kidney with a kinked ureter one notices that there is little urine during the attack but a flood of it afterward; palpation may reveal the kidney and rigidity is at a higher level than in appendicitis. If renal calculi are present they may be demonstrated by means of the *x*-ray. For differential diagnosis the *x*-ray has little value in suspected acute appendicitis because thorough cleansing of the intestinal tract is necessary to avoid intestinal contents being mistaken for calculi and this purgation is not merely dangerous from loss of time but because it may spread infection should the disease be appendicitis. In chronic cases the *x*-ray may give very valuable information. It is only very early in a case of renal colic that one is liable to mistake it for appendicitis.

Nephritic and Perinephric Abscess.—The only forms of appendicitis with which these abscesses could be confounded are those in which the appendix is situated behind or to the outer side of the cecum. Many perinephric abscesses are in fact of appendicular origin and as in all, the treatment is by lumbar incision the differential diagnosis is of little importance.

Hernia.—A very recent and small hernia has occasionally been mistaken for appendicitis. Careful examination should preclude such error. An appendix may lie in a hernial sac, even on the left side, and when inflamed give the symptoms of strangulated hernia. Such a condition is only discoverable by operation.

Pyosalpinx and Ovarian Abscess.—In these diseases there is usually the history of vagino-uterine infection. The septic fever in acute cases and the presence of an inflammatory mass, readily felt on bimanual examination, and which immobilizes the uterus, makes diagnosis easy. Inflammation of an appendix lying in the pelvis and adherent to the uterus and adnexæ may give all the palpable signs of pyosalpinx.

Ovarian Cyst with Twisted Pedicle.—When an ovarian cyst has become strangulated through torsion of its pedicle the condition becomes one of acute inflammation and unless the cyst has been known to be present or its shape, consistency and position lead one to recognize it, the diagnosis must be "an acute inflammatory lesion probably of appendiceal origin," this probability being based on the great frequency of appendicitis.

Extrauterine Pregnancy.—The history is of very great importance. Usually there has been sterility for a number of years. The menses cease in whole or in part and some of the signs of pregnancy appear. Suddenly there is intense abdominal pain with evidences of internal hemorrhage, *e. g.*, shock, anemia, etc. The pain is paroxysmal but not colicky. The uterus expels its decidual contents as an irregular bloody discharge mixed with more solid shreds of tissue. This is naturally often taken to be an ordinary abortion. Bimanual examnation usually clears up the diagnosis by revealing the characteristic tumor in the broad ligament or in Douglas's pouch. If seen late, infection of an extrauterine hematocele may give signs identical with those of appendicitis.

When the pregnancy is confined to the right tube, rupture not having occurred and vaginal discharge being absent, should pain and tenderness be present, differential diagnosis may be very difficult and unimportant from a therapeutic standpoint as in both operation is indicated.

Dysmenorrhea.—Dysmenorrhea may give symptoms like those of appendicitis but its periodicity aids in diagnosis. The pain is paroxysmal, is localized from the first and is usually bilateral. Vaginal examination may make the diagnosis certain. One must not forget that appendicitis may, especially in young women, give rise to painful menstruation.

Lead Poisoning. Plumbism.—The colic of lead poisoning is usually paroxysmal and relieved by pressure. There may be dull heavy pain between the paroxysms. "Localized pain, slight fever and moderate leukocytosis may be present. The cases may simulate intestinal obstruction. The history, the presence of a blue line on the gums and the blood changes are of importance in differential diagnosis." (Osler.) The blood changes consist of a moderate anemia; many of the red cells show a granular basophilic degeneration. Even though these changes are common in other diseases such as sepsis they are most numerous in plumbism. The presence of nucleated red cells is of value in diagnosis.

Pleurisy and Pneumonia.—The early symptoms of these diseases have caused many errors but careful routine examination of the chest should lead to correct diagnosis.

Herpes Zoster.—The segmental pain of herpes may lead to a suspicion of appendicitis but the eruption of the characteristic vesicles on the second or third day will clear up the diagnosis.

Hysteria. Pseudo-appendicitis.—Neurotic patients can unconsciously give a very perfect imitation of almost any disease. Usually the stigmata of hysteria can be found. The prominent tenderness and rigidity may entirely disappear if examination is made while the patient's attention is distracted. Fever is usually absent. One should remember that a hysterical subject may suffer from appendicitis, and therefore one should be exceedingly cautious before concluding that no appendicitis is present.

COMPLICATIONS IN APPENDICITIS.

Peritoneal Complications.—When the body is lying flat with both shoulders and buttocks touching the table or bed there are three dependent cavities, viz., the pelvis and the two flanks or kidney pouches. Water poured into the abdomen must gravitate to these cavities and form pools. The flank pools are separated from each other by the bodies of the lumbar vertebræ and by the root of the mesentery which runs obliquely across the spine from above downward and from left to right. The pelvic pool is separated from the rest of the abdomen by the promontory of the sacrum and the brim of the pelvis. Pus from an appendiceal abscess must drain into one or more of these pools except as it may be hindered by adhesions, omentum, mesentery or distended loops of intestine. Subdivisions of these pools are created by such structures as the mesosigmoid, rectum, ascending and descending colons and by the transverse mesocolon. The examination of cadaver tends to make one forget that distended loops of intestine form very efficient pneumatic barriers to the spread of infective fluids. Examples of such protection are the transverse colon pressing against the anterior abdominal wall preventing general peritoneal infection in acute cholecystitis; and similar action of the ascending colon localizing pus in appendicitis

when the appendix lies to the outer side of the colon. In both these examples the omentum, of course, greatly aids in the protection.

In the case of non-fulminating appendicitis the diffusion of toxins in advance of the bacteria which produce them, gives rise to irritation of the peritoneum with consequent exudation of coagulable material all over the appendix and the neighboring peritoneum. As a consequence any structures which come in contact with the altered appendix tend to adhere to it, and thus it can be walled off from the general peritoneal cavity by a barrier of intestine, omentum, parietes, etc. The isolation may be so thorough that by the time the infective agents can follow their toxins through the walls of the appendix or perforation can take place, the infection or extruded appendiceal contents find their entrance into the open peritoneum blocked by a very efficient rampart and a localized periappendicular abscess results.

When the appendix is situated below the cecum the abscesses to which it may give rise are bounded above by the cecum and ileum, anteriorly and posteriorly by the abdominal wall, internally by omentum or if extensive by the sigmoid and rectum. The abscesses often extend into the true pelvis filling up Douglas's pouch. An abscess may extend in front of the rectum and form a secondary cavity to the outer or left side of the sigmoid. A more common extension is between the mesentery of the ileum and the mesosigmoid.

When the appendix lies along the outer side of the ascending colon, the abscess is bounded internally by the ascending colon, externally and anteriorly by the parietes. Such an abscess unless prevented by adhesions is very likely to spread upward until it reaches the subhepatic fossa from which it may pass (rarely) through the foramen of Winslow to the lesser peritoneal cavity, or in front of the liver under the diaphragm to form a subphrenic abscess.

A localized pelvic appendix abscess may escape up either loin. When it does so on the left side it spreads up either the internal or external lumbar fossa to the left anterior intraperitoneal fossa.

When the appendix lies hidden in the connective tissue behind the cecum and colon the resulting abscess is retroperitoneal. Retroperitoneal abscesses may arise by extension of the infection through the mesoappendix and also through the lymphatics. Jackson has clearly pointed out the grave dangers to be expected in retrocecal appendicitis.

Whether the abscess is a result of diffuse cellulitis or lymphangitis the infection may spread to the extraperitoneal cellular space between "the layers of the coronary ligament or to the lesser omentum and its glands." (Barnard.)[1]

An epigastric abscess may form from extension of infection along the lymphatics around the deep and superior epigastric arteries. All the subphrenic spaces and fossæ may be infected from appendicitis, except the left extraperitoneal cellular space. Out of 76 cases of

[1] British Med. Jour., February 22, 1908.

subphrenic abscess studied by Barnard 26 were the result of gastric or duodenal ulcers and 12 of appendicitis. Spread of infection through the diaphragm is not uncommon, giving rise to pleuritis or even pulmonary involvement.

If during the early course of appendicitis intestinal peristalsis is encouraged by the administration of food and laxatives one loop of bowel after another can come in contact with the infection and carry it off to distant parts of the abdomen, giving rise to multiple abscesses.

When owing to the rapidity of the disease process there has been no time for protective adhesions to form and especially when purgatives have stimulated peristalsis the infection may be quickly spread out over a large part of the peritoneum giving rise to spreading, diffuse or generalized peritonitis.

If the source of the peritoneal infection be a gangrenous appendix such an enormous dose of potent toxins may be suddenly thrown into the peritoneum that the resisting powers of the body are promptly annulled. As inflammation is merely a means of resisting noxious influences no inflammation is here possible. There is no pus or fibrinous deposit, though some foul-smelling blood-stained serum may be present. The condition is one of profound septic intoxication. If the patient survives the shock and collapse the resisting power may return and peritonitis result.

Absorption of infections through the ileocecal veins may cause acute inflammation of the portal vein (pylephlebitis) and multiple abscesses in the liver and spleen. Next to typhoid fever appendicitis is the commonest known cause of cholecystitis and cholelithiasis. Hematemesis as a complication of appendicitis has been already discussed.

Phlebitis.—Phlebitis especially of the left femoral vein is not uncommon after appendicitis as also after many intra-abdominal operations.

Jaundice.—Jaundice, often referred to as a complication of appendicitis, is, of course, merely a symptom of profound toxemia or of some interference with the function of the liver or bile ducts.

Intestinal Obstruction.—Intestinal obstruction due to mechanical interference with the passage of the intestinal contents is not common during an attack of acute appendicitis, it is much less uncommon as a sequel to the disease. The appendix itself may become adherent, *e. g.*, by its tip, to some other structure and so form a band which may press upon and obstruct a portion of the gut. The adhesions, which during the attack protect the general peritoneal cavity, may subsequently cause angulation or kinking of the intestine or may become constricting bands. Any of these conditions may occasion acute or chronic intestinal obstruction. Acute obstruction occasionally arises soon after appendectomy or any other intra-abdominal operation and unless promptly relieved by operation usually leads to a fatal result.

Mechanical obstruction must not be confounded with the physiological obstruction which acts beneficially in acute appendicitis nor with the paralytic obstruction of generalized peritonitis.

Ovarian or Tubal Disease.—Ovarian or tubal disease may develop by direct extension from an inflamed appendix or by passage of infection through a fold of peritoneum which runs from the mesoappendix to the ovary (Clado's ligament).

The protective adhesions of acute appendicitis may on recovery cause kinking or immobility of the Fallopian tube with consequent disease in the same way that the adhesions due to acute pyosalpinx may later so disable the appendix that appendicitis is fostered.

Symptoms of Complications.—*Symptoms of Periappendicular Abscess.*—In addition to the classical symptoms of appendicitis, tumor usually manifests itself. Tumor may be observed as early as the first or second day of the disease but this is rare as it usually takes several days to develop. Tumor *per se* does not mean abscess but when taken in conjunction with increasing pain and tenderness, with a rise in the temperature and pulse-rate it is so strongly indicative as to be almost diagnostic. When pus is present a rise in the leukocyte count, especially that of the polymorphonuclears, may be of value. It must be remembered that abscess may be present even though the temperature, pulse, and leukocyte count are normal. If tumor cannot be felt on gentle palpation no enthusiastic search for it by vigorous fingering is permissible because of the dangers of rupture. Rectal or vaginal examination often reveals a tumor which is not palpable through the abdominal wall. This is particularly true in the case of children. The tumor while frequently in the right iliac fossa may be found in the middle line, on the left side, in the pelvis, extending along the course of the ascending colon or far back in the right loin. When the mass is retrocolic nothing may be palpable. Absence of a palpable tumor does not mean absence of pus.

William Ewart[1] lays great weight on the value of dorsal percussion in the diagnosis of retrocecal and subcecal appendicitis. Between the resonant sacral and iliac surfaces there are two posterior iliac patches of subresonant dulness (Fig. 17) which can be mapped out by using a pleximeter (Ewart advises Sansom's). The right patch is normally rather duller than the left. After an operation for appendicitis there may be no remnants of dulness left in the right patch or there may be specially resonant tympany. In cases of retrocecal appendicitis or abscess Ewart finds increased dulness of the right patch and dulness of adjacent parts of the right ilium. In a number of cases where abdominal signs were absent Ewart by dorsal percussion was able to make a correct diagnosis.

When subphrenic abscess develops local pain is a prominent symptom. The evidences of sepsis are increased (dirty and often dry, cracked tongue; pale, anemic face; profuse sweats and great thirst; great loss of weight; generally septic diarrhea though there may be constipation; fever usually about 100 to 101°, occasionally 105°; pulse-rate varies much according to the degree of localization of the abscess

[1] British Med. Jour., December 29, 1912.

and virulence of the infection, it may be normal or it may be uncountable; rigors are occasionally present and are serious in prognosis). Abdominal tumor is usually to be found and consists either of the liver or of the abscess itself. The falciform ligament prevents a right-sided abscess from passing to the left, and *vice versa*. A right extra-peritoneal subphrenic abscess may push into and separate the layers of the falciform ligament and point in the epigastrium.

The symptoms of spreading and of diffuse peritonitis have been already sufficiently discussed in connection with acute appendicitis.

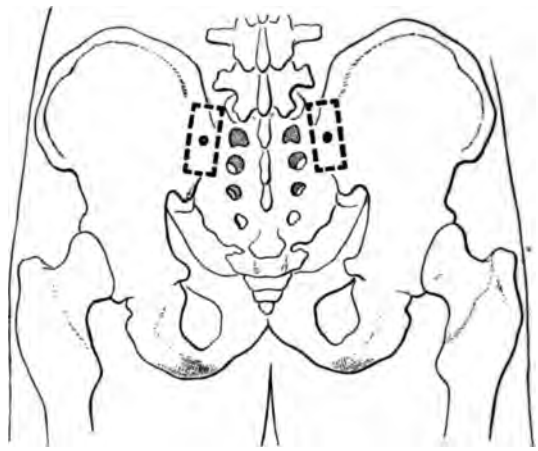


FIG. 17.—Areas of subresonant dulness. (Ewart.)

TREATMENT OF APPENDICITIS.

There can be no question as to the treatment of acute appendicitis when it is seen early. Everyone agrees that immediate operation is the only sensible treatment to adopt provided that a reasonably efficient operator is available and that the patient can be removed to a hospital or his home surroundings arranged so that he can be cared for properly. If one can remove all the infection bottled up in the appendix then the operation, properly carried out, is a slight one and the results are all that could be desired. Every case of acute appendicitis should be recognized and operated on within twelve or twenty-four hours of the beginning of the attack. If this were done the mortality of the disease would be almost *nil* and the inconvenience and confinement incident to the operation would be really trivial.

When abscess is present there is little doubt that operation should be promptly performed for evacuation of the pus. There are doubts, however, as to the propriety of hunting for and removing the appendix in every case of appendiceal abscess. In the very young and the aged non-operative treatment is admittedly dangerous in any stage of appendicitis. The very young are not well provided with omentum with which to localize abdominal infection; it is difficult or impossible

to keep them absolutely quiet in bed and such quietness plus starvation is the *sine qua non* in non-operative treatment.

The aged cannot stand confinement to bed and rigid starvation. For young children and the aged operative treatment is proper at any stage of acute appendicitis except in one where it is clearly too late. It is stupid and cruel to operate for appendicitis when the subject is clearly in *articulo mortis* yet this is often done.

Non-operative Treatment.—Nature cures appendicitis either by making the appendix evacuate its contents into the cecum or by limiting the spread of infection from the inflamed appendix. The first of these natural methods of cure applies principally to early cases of endoappendicitis, appendicular colic or obstruction and may be stimulated by the administration of castor oil. While one dose of a purgative such as castor oil may and often does lead to immediate relief yet, if it fails to produce evacuation into the colon, the induced peristalsis is very likely to cause perforation of an already tense and softened appendix and to cause dissemination of any infection which has escaped through the walls of the appendix. The exhibition of any purgative during an attack of acute appendicitis seems to the writer entirely unjustifiable. Nature's first method of treatment is therefore not one to be imitated or encouraged.

The second natural method of treatment is to segregate the inflamed organ and prevent the spread of infection from it throughout the peritoneal cavity. As has already been indicated Nature endeavors to do this by surrounding the focus of infection by omentum which rapidly becomes adherent to it and by loops of intestine distended with gas and forming very efficient cofferdams. If these natural methods of localizing infection are not impeded by injudicious treatment but are encouraged, there will be extremely few cases of general peritonitis. One must never forget that every case of appendicitis should have been operated upon before the infection had time to penetrate the wall of the viscus. As stated elsewhere children and the aged are unsuited for non-operative treatment.

In his writings on intestinal obstruction H. O. Thomas at a very early date formulated a method of treatment which anticipated in almost every point Ochsner's well-known views.

Thomas believed that the exhibition of purgatives or of enemata could convert a mild functional obstruction into a fatal one; that no patient ever died from starvation due to obstruction; that pain and vomiting were the great weakening agents; that a large number of cases of obstruction might be expected to recover if food, purgatives and enemata were absolutely withheld, and if morphin were given to allay pain and peristalsis.

In practice Thomas used morphin freely even several times daily for weeks, discarded purgatives and enemata and prohibited milk. What food and drink he gave was in the form of thin arrow-root, rice, barley all made with water and perhaps flavored with wine. After many days the patient would pass much gas, then dry scybalæ, later

a pultaceous stool and still later very free watery stools. Thomas "always looked upon this stage as a critical one and enjoined perfect rest and quiet for several days, when the restrictions in regard to diet were by degrees removed."[1]

The modern equivalent of Thomas's treatment is Ochsner's.

Ochsner's non-operative treatment of appendicitis which is "too late for early operation and too early for late operation."

1. Treat vomiting and distention by washing out the stomach by means of the stomach tube. To avoid distress Ochsner often precedes the lavage by giving hypodermically morphin gr. ¼, and by spraying the fauces with cocain. It is rarely necessary to wash the stomach more than twice.

2. Place the patient in bed and keep him there. Do not let him rise for any purpose. Let him lie as quietly as possible. This treatment is impossible in children and risky in the aged.

3. Prohibit the use of purgatives and ordinary enemata. To provide water, salt solution may be given per rectum by Murphy's method or an enema consisting of one ounce of predigested food in three ounces of salt solution may be given every four hours.

4. To discourage peristalsis prohibit the giving of any food or water by the mouth.

If these apparently simple but really strenuous or even cruel rules are faithfully carried out, almost every case of appendicitis not actually moribund, will clear up in a few days or the lesion become so well localized that if pus forms its evacuation becomes the simple opening of an abscess.

Operative Treatment.—Methods of Opening the Abdomen.—*Gridiron Incision* (McBurney-McArthur).—This incision is very valuable in cases where extensive exploration is not necessary. The principle involved in the method is excellent, viz., the splitting in the direction of its fibers of every tissue penetrated and the avoidance of division of nerves.

Make a three-inch incision through the skin and subcutaneous fat beginning at a point one inch above a line joining the anterior-superior spine and the umbilicus and crossing it at a point one and a half inches from the anterior-superior spine. The incision runs downward and inward parallel to the fibers of the external oblique muscle and aponeurosis through the whole length of the wound but does not cut any of them transversely.

Retract the edges of the wound in the external oblique and expose the internal oblique whose fibers run approximately at right angles to those of the external oblique.

Traverse the internal oblique and under it the transversalis muscle by separating and retracting their fibers. Blunt retractors with blades about two inches deep by one and a half inches wide are very useful in gaining exposure.

[1] Liverpool Med. Inst., October, 1913.

Open the peritoneum with special care as it is frequently adherent to the cecum or other abdominal contents.

When the active operation is completed the wound is closed in layers by a few catgut sutures. The various structures having been split in the direction of their fibers, any muscular action tends to close the wound instead of to make it gape hence few stitches are required except in the skin and there is little danger of hernia. Drainage if required may be provided through a special stab wound or through the incision itself.

Should the gridiron incision be insufficient in size it is best enlarged medially by continuing the split in the external oblique transversely across the rectus muscle and dividing this muscle and tying and dividing the deep epigastric vessels.

Division of the rectus is much preferable to Weir's plan of transverse section of the aponeurosis in front of and behind the rectus, with retraction inward of the rectus itself, as it gives more exposure, both recti may, if necessary, be divided, and does not destroy any of the nerve supply to the rectus. Suture of the rectus muscle does not leave any particular weakness; it merely makes a new tendon inscript.

Transverse Incision.—Make a transverse incision down to the right rectus muscle along a line joining the two anterior-superior iliac spines. Incise the anterior layer of the rectus sheath. Above and below the aponeurotic incision insert a suture transversely to unite the rectus muscle to the aponeurosis and to prevent it from retracting into its sheath. Divide the muscle transversely. Expose and doubly ligate the deep epigastric vessels before dividing them unless it is possible to retract and preserve them. Open the peritoneum. The base of the appendix usually lies opposite Lanz's point which is at the junction of the middle and right thirds of the bispinal line. If it is necessary to enlarge the wound this may be done: (*a*) By continuing the cut outward and upward; (*b*) by splitting the aponeurosis of the external oblique outward and upward and so exposing and splitting the internal oblique and transversalis muscle, in fact by making the familiar gridiron incision *after* having divided the rectus; (*c*) by continuing the incision across the left rectus.

Closure of the transverse incision is very easy and gives a good strong reconstruction.

Right Rectus Incision.—Make a two and a half to three-inch vertical incision about one finger-breadth internal to the outer edge of the rectus. The upper end of the incision is one inch above the line uniting the anterior-superior iliac spine to the umbilicus. Incise the anterior layer of the rectus sheath. Split the muscle or retract it inward (Kammerer, Battle, Jaboulay, Lennander), and so expose and divide the posterior layer of rectus sheath. This incision is a good one and easily enlarged. Its principal disadvantage is that much of the nerve supply to the rectus is necessarily divided or torn. This disadvantage seems more academic than practicable, as a disabling or annoying paresis of the rectus is rare.

Oblique Incision.—An oblique incision, which roughly follows the direction of the fibers of the external oblique, may be made in any position desired over any inflammatory mass resulting from appendicitis.

Methods of Finding and Isolating the Appendix.—Often, especially in acute appendicitis, the offending organ floats into view or almost "pops" into the wound as soon as the peritoneum is opened. Sometimes the appendix makes its appearance at the wound as soon as a few soft adhesions are gently separated by the finger. Generally a more systematic search is necessary:

(*a*) Pass the finger gently, everything must be done gently, along the outer surface of the cecum and in contact with the outer and posterior abdominal wall over the brim of the pelvis. Note the pulsating iliac artery. Slip the finger upward along the artery and hook the finger slightly as it passes out of the pelvis. The hooked finger brings up a loop of ileum close to the cecum and within an inch of the base of the appendix. As the most common site of the appendix is the ileocecal fossa or angle the above maneuver usually brings the appendix itself into view or at least demonstrates its position.

(*b*) If the cecum is mobile it may be pulled into the wound and the appendix easily located.

(*c*) If the above maneuvers fail to reveal the appendix note the anterior longitudinal muscular band on the colon and cecum. Follow the band to the fundus of the cecum, it inevitably leads to the base of the appendix. If the band seems to disappear into the reflection of the peritoneum from the cecum to the parietes it means that the appendix is retrocecal. To expose an appendix buried behind the cecum or ascending colon make an incision through the parietal peritoneum parallel and just external to the cecum. With the fingers introduced through this incision burrow under the cecum and lift it from its bed, thus mobilizing it without jeopardizing its blood supply. The appendix will be found in the exposed connective tissue; it is not provided with a meson and it may lie in close proximity to the ureter. If an appendix situated just external to the cecum and colon is thoroughly covered by adhesions it may appear very like the retrocecal variety and require similar treatment.

(*d*) When on account of adhesions isolation of the appendix is difficult it ought to be carried on as far as possible under guidance of the eye. In dividing short adhesions one must remember the rule to sacrifice part of what is being removed, if non-malignant, rather than to injure the wall of an important viscus; if necessary some of the wall of the appendix, never containing mucosa, may be left attached to a segment of gut so as to avoid laceration of the gut wall. Frequently isolation of the appendix is facilitated by early division of its base and removal of the organ from base to tip. To do this apply two ligatures or clamps to the base of the organ and after dividing between them thoroughly sterilize the open lumen with the cautery or liquid carbolic acid.

Treatment of the Mesenteriolum.—The appendix having been isolated note the size and condition of its meson. If the meson is of fair length perforate it beside the base of the appendix, pull a ligature through the perforation, ligate the meson and divide it distally to the ligature. Sometimes a chain of ligatures is required and occasionally the meson is so short that it must be divided without preliminary ligation, any bleeding points being secured by forceps as the division proceeds.

Methods of Treating the Stump of the Appendix.—(*a*) Tie a chromicized catgut or a silk ligature tightly around the base and remove the appendix. Destroy all the exposed mucosa and sterilize the stump with the cautery or carbolic acid. This simple method is probably as good as any of the more complicated plans and is safer than some which have been recommended.

(*b*) Ligate with fine catgut, remove the appendix, sterilize the stump. Surround the stump with a purse-string suture of fine silk. With a forceps invaginate the stump into the cecum, at the same time tighten and tie the purse-string suture.

(*c*) At a point about one-fourth of an inch from the colon make an incision around the appendix through the serosa alone. Reflect the serosa toward the cecum as a cuff. Close to the cecum ligate the remaining tube of mucosa and muscularis and remove the appendix. Cover the stump with the cuff of reflected serosa.

When appendicitis is accompanied by an abscess of moderate extent the operation is very similar to that already described. Before invading any abscess cavity it is wise to protect the peritoneal cavity with strips or pads of gauze unless the insertion of these would spread infection by pushing pus ahead of them. While isolating the appendix pockets of pus may be encountered. These should be carefully cleansed by sponging before further progress is attempted. The appendix having been isolated its stump is treated by one of the methods described or if it is too soft and friable to hold a suture or ligature it is removed without any special stump treatment or should the cecal wall be healthy the hole in the gut wall, resulting from the removal of the appendix, may be closed by sutures. After the appendix has been removed, gently search for other pockets of pus especially in the pelvis. If the appendix is retrocecal the pus is liable to burrow toward the liver and hence a counter-opening just external to the lumbar mass of muscles may be necessary for efficient drainage. After thoroughly cleaning the territory of operation with moist gauze, remove the protective pads and provide drainage by means of split rubber tubes or of strips of folded rubber tissue or dam. Many surgeons prefer cigarette drains. Instead of gauze, many British surgeons use strands of woolen yarn in their cigarette drains as being more elastic and less liable to clogging. Close most of the wound with sutures. Apply abundant dressings.

The best after-treatment is identical with the Ochsner non-operative treatment.

When appendicitis is accompanied by a large abscess the incision is usually made over the prominent swelling or a little external to it. If during the dissection any part of the wound seems to be particularly edematous one may be sure pus is close at hand and that the edema will act as a guide to it.

The abscess should be opened carefully, the opening being enlarged by blunt dissection. Very many surgeons end the operation as soon as the pus is encountered, satisfying themselves with provision for ample drainage. This practice is eminently safe.

Other surgeons explore the cavity so as to remove any fecal concretions, and the appendix if it is accessible, but they carefully refrain from any manipulations which would jeopardize the integrity of the abscess walls.

Knott and many others prefer to open the abdomen near the abscess, protect the peritoneum with gauze pads, systematically break down *all* adhesions, mop away all pus, remove the appendix in every case, provide tubular drainage especially in Douglas's pouch, partially close the wound, apply dressings, place the patient in Fowler's position or lying on his right side, and administer salt solution by Murphy's rectal instillation.

Each of these methods gives excellent results but the writer feels safest when he does as little interfering as possible. After recovery it is easy to remove the quiescent appendix.

Maylard,[1] after evacuating the pus swabs the abscess cavity with liquid carbolic acid, removes all excess of the acid and then smears the cavity with iodoform and provides both tubular and gauze drainage.

Waterhouse,[2] after removing the pus, pours about one ounce of ether into the cavity and permits it to boil away.

If an appendicular abscess, situated in the pelvis, causes bulging into the rectum, A. Maclaren[3] advocates rectal incision and drainage.

When an appendicular abscess is so situated that it cannot be reached without going through the peritoneal cavity, *i. e.*, when it is not adherent to the parietes, one must protect the belly with gauze pads, evacuate the pus, remove the appendix, cleanse the abscess cavity as thoroughly as possible, and provide free drainage.

Treatment of Spreading or of General Peritonitis Secondary to Appendicitis.—The non-operative or Ochsner treatment faithfully and intelligently carried out gives excellent results; it is *not* properly applicable to children or the aged.

The operative treatment may be carried out in one of two manners:

(*a*) Open the abdomen through any convenient incision under local, spinal, nitrous oxide or ether anesthesia (never chloroform). Crile's anoci-association may be useful. Remove the appendix in the simplest manner possible. Introduce a large drain to Douglas's pouch. Do not mop the peritoneum; do not irrigate. Place the patient in Fowler's position and administer salt solution by Murphy's rectal instillation.

[1] British Med. Jour., 1911, i, 676.
[2] Ibid., 1915, i, 233.
[3] Trans. Surg. Sect., A. M. A., 1914.

(*b*) Same as preceding, but after removal of the appendix irrigate the peritoneal cavity by passing to every part of the cavity a large blunt tube, attached by a large pipe to an irrigator, and thus flush the peritoneum from the healthy to the diseased areas. Keep up the irrigation until the water returns clear. Close the abdomen without a drain unless the latter is absolutely indicated because of the presence of non-absorbable amounts of necrotic material.

Numerous methods have been used, besides flushing, in an endeavor to overcome the peritoneal infection.

E. J. Johnson[1] retracts and elevates the abdominal incision and fills the abdomen and pelvis with a 2.5 per cent. solution of iodin in alcohol, making sure that the solution reaches all the peritoneal fossæ. He then removes the appendix and gently mops out the excess solution and débris, avoiding scrubbing and trauma. Drainage, the Fowler position and the administration of salt solution are used as routine.

Some surgeons after evacuating the pus introduce camphorated oil into the abdomen.

Sencert, Bainbridge and others fill the peritoneal cavity with oxygen. Berard and Vignard are enthusiastic over flushing with oxygen.

Morestin recommends that ether be poured into the abdominal cavity and left there. Waterhouse has had excellent results from ether used as follows: Introduce a rubber drain, provided with two lateral openings, into the pelvis. About eighteen inches of the tube should project from the abdominal wall. Close the abdominal wound snugly around the tube. By means of a funnel pour not more than three ounces of ether through the tube into the abdomen. Clamp the tube to prevent escape of the ether. After the lapse of three or four hours remove the clamp. Leave the tube *in situ* for forty-eight hours.

Crede[2] opens the abdomen, removes the appendix, provides gauze drainage (preferably with his silver gauge), introduces 20 to 50 grams of a 1 per cent. solution of collargol to all diseased areas and over the intestines, does no mopping except to remove sloughs. He next places two to three tablets of collargol (0.05 gm.) in the various peritoneal pouches—these he thinks are quickly absorbed and act as an intravenous injection of collargol. Immediately after operation he gives sennatin by intramuscular injection.

Murphy's method of rectal instillation, or proctoclysis, has been mentioned several times in the preceding pages. As the treatment is commonly wrongly carried out and as various specialized pieces of apparatus have been recommended to simplify, though really they spoil, the method it may be proper to describe the correct apparatus and its use.

"A fountain syringe or can with a large rubber tube attached, terminating in a vaginal hard-rubber or glass tip flexed at an obtuse angle two inches from its tip, having numerous openings, is the entire apparatus. It should be inserted so that the angle fits closely to the

[1] Crisler and Johnson: Jour. Arkansas Med. Soc., October, 1914.
[2] München. med. Wchnschr., lx, 2117.

sphincter and the tube then bound firmly to the thigh with adhesive strips, so that it may not be expelled. The can is suspended from the foot of the bed so that its base is six inches above the level of the patient's buttocks. Once the irrigating apparatus is thus placed, it need not be disturbed for several days, unless to increase or diminish the speed of influx. A pint and a half of solution is now placed in the can at a temperature of 100° and should be kept at this temperature by applied heat (hot water bags, thermolytes, or an incasing can of hot water). It should require not less than forty nor more than sixty minutes for the pint and a half of solution to percolate into the bowel, being uniformly absorbed in this time; but if administered more rapidly it will be expelled. The control of the flow should never be governed by knots in the tube, forceps clamped thereon, or small openings in the tip. The larger tube with many openings is used to provide for a sudden return of the flow into the can when the patient strains, wishes to expel the fluid or void gas. The proctoclysis is usually continued for three days, rarely as long as five or six." (Murphy.)

APPENDICITIS IN CHILDREN.

Appendicitis occurring in children requires especial consideration not because of the absence of the classical symptoms, but because they are so difficult to elicit and may be so masked. Furthermore, appendicitis from anatomical and physiological reasons is even more dangerous in the very young than in adults.

In spite of the natural dread of being thought an alarmist the physician ought to examine carefully for appendicitis in every child suffering from colic and vomiting and not pay too much attention to the domestic diagnosis of "stomachache," "biliousness" or "too much Christmas," which last is often the cause of an acute attack.

In examining a child one should sit quietly beside it, listen to its complaints, play with it, lay the warm hand gently on the abdomen and, distracting the patient's attention, examine for rigidity, tenderness, etc. Unless great care is taken the child may be so frightened that any satisfactory examination is impossible. Vomiting and abdominal pain are common in children after any indiscretion in diet but usually they soon disappear after the stomach has emptied itself. If the vomiting and pain continue and if the bowels do not act regularly and especially if there is constipation one must think of appendicitis. An elevation of temperature is indicative of appendicitis rather than of any functional disturbance. The state of the pulse and even of the temperature is less informing in children than in adults as they react so quickly to any toxemia or excitement.

Ochsner is of the opinion that colicky pains regularly referred to the umbilical region in children, accompanied by discomfort or nausea elicited by pressure made at McBurney's point surely indicate a foreign body present in an abnormal appendix. The presence of bloody

mucus in the stools with cramping pain in the abdomen coupled with ileocecal tumor indicates intussusception but from a therapeutic standpoint the differentiation is not of much importance as in both an immediate operation should be urged.

Rectal examination, sometimes under light anesthesia, is very important in children when the abdominal physical signs are negative. It is absolutely obligatory to carefully examine the chest in children as pneumonia so often gives marked abdominal symptoms. The early symptoms of measles sometimes simulate appendicitis and to make the problem more complex the two diseases may coexist (Finney).

Appendicitis is more frequently mistaken for coxitis than coxitis for appendicitis. One should also remember the possibility of psoas abscess and of osteomyelitis in the ilium or high in the femur. Finney attributes great diagnostic significance to pain in association with flexion of the thigh or accompanying micturition. There can be no room for difference of opinion regarding the treatment of appendicitis in children. The only non-operative treatment which is ever justifiable in appendicitis is absolute rest. For obvious reasons this is impossible to attain and the starvation necessary for intestinal rest is badly borne by children. While in adults the omentum can serve a most useful function in localizing infection it is commonly so poorly developed as to be useless in the young.

Whenever appendicitis is known to be present in a child operation should be promptly performed. The course of the disease may be so rapidly fatal that delay is unjustifiable. Having taken reasonable care in diagnosis it is far less serious to have operated unnecessarily than to have waited until too late.

DIAGNOSIS AND TREATMENT OF THE DISEASES OF THE LARGE INTESTINE.

By LEWIS STEPHEN PILCHER, M.D.,

AND

JAMES TAFT PILCHER, M.D.

EMBRYONAL DEFECTS OF THE LARGE INTESTINE.

Imperfect Rotation of the Colon.[1]—Failure of the colon to rotate completely may or may not coëxist with a transposition of the other organs. Normally by the end of the eighth week in the fetus the cecum has begun migrating upward from the left iliac fossa and to the right, a movement due to the rapid growth of the small intestine in comparison with the very slow development of the large gut. The colon being on the fixed axis of the mesentery at the origin of the superior mesenteric artery, rotates across the abdomen to the right in front of the duodenum and comes to lie under the liver at about the fourth month, from which situation it gradually descends to its ultimate position in the right iliac fossa, which is usually reached at about the time of birth. The cecum may be arrested in any position in its course of rotation (Figs. 18 and 19). Subsequent disease in a cecum so arrested will occasion a confusing symptomatology unless the above possibility be taken into consideration. Thus are to be explained instances of left-sided appendicitis or fixation of the appendix to the stomach, gall-bladder or duodenum. The first thing one should search for, when difficulty is encountered in locating the appendix, is whether or not a condition of nonrotation is to be dealt with. The one pathognomonic finding which indicates to the examiner immediately a condition of non-rotation is the exposure of a movable duodenum, which in these cases has a definite mesentery and merges directly into the jejunum and is not covered as usual by the transverse colon and its mesentery. Also one should think of such a com-

[1] Dr. James E. Davis (American Journal of Obstetrics, March 1916, p. 474) reports the results of the examination of two hundred and eighty-five cadavers, with reference to the position and deviations from the normal of the various segments of the colon. Of the whole series only 35.5 per cent. of the colons examined presented a normal morphography; in 9.9 per cent. there were persisting embryologic forms; in 0.9 per cent. there was incomplete descent of the cecum. Adhesions were at the hepatic flexure in 5.8 per cent.; at the gastric area in 4.2 per cent. and at the ileocecal region in 7.5 per cent. The hepatic flexure appeared in very acute angulation in 21 per cent. The transverse colon was the subject of marked ptosis in 23.4 per cent. There were marked constrictions in 2.3 per cent.; diverticula in 0.9 per cent.; gigantism in 0.9 per cent. There were convincing evidences of etiologic conditions for constipation in 55 per cent.

plication in young people, particularly in those who present some inflammatory process of the left iliac fossa. The only certain method of diagnosis is radiographic demonstration of the course of the large intestine.

A cecum arrested in the left hypochondrium, with a long meso has been found as the most frequent element leading to volvulus of the cecum.

FIG. 18.—Imperfect rotation of colon. Skiagraph of large intestine after distention by a bismuth enema. Note retention of entire colon in left half of abdomen. Sharp angulation and constriction at the junction of the ascending and transverse colon causing imperfect filling of the cecum; cecum (as shown by subsequent abdominal section), lying free in upper left pelvis; transverse colon convoluted. See history of case in text. (Pilcher Hospital, No. 997.)

Pericolitic Veils and Bands.—Another condition often met with is a pannus-like film extending from the right abdominal wall over to and enfolding varying portions of the cecum and ascending colon (Jackson's membrane). Such a film is, in many instances, primarily of a developmental origin, but in the cases which assume surgical interest infective and traumatic processes have been superadded whereby the original delicate films have become thickened and trans-

formed into contracting sheets and crippling bands that seriously interfere with peristaltic power.

Cecum Mobile.—The cecum even when normally descended varies greatly in the extent and manner with which it is fixed to the lumbar wall. It may be held by a more or less well-defined mesocecum; the usual retrocecal connective tissue may be redundant and flaccid, associated with a long mesocolonic attachment of the ascending colon and hepatic flexure, rendering possible a marked ptosis of the whole right cecocolonic tract, or, in other instances, a tendency to twist at the hepatic flexure. Such mobility of the cecum and an unduly long mesocolon predispose to ileocecal and cecal invaginations. (See Intussusception, p. 156.) The mere descent of the cecum is

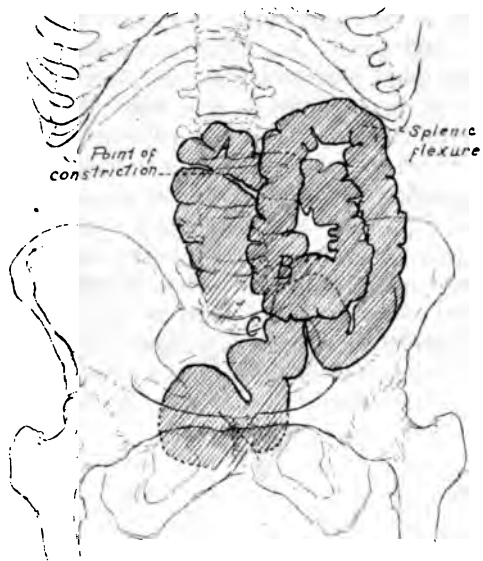


FIG. 19.—Imperfect rotation of colon. Diagrammatic interpretation of Fig. 18. *A*, constricted and angulated hepatic flexure; *B*, convoluted transverse colon; *C*, cecum opposite left sacro-iliac synchondrosis.

itself of comparatively little importance. The thing that counts is the readiness with which it may propel its contents onward. Ptosis of the cecum, with increased contractile power in its walls and absence of obstructing conditions beyond it, is compatible with health and may exist without symptoms; with lessened contractile power, such as might result from some degree of inflammatory disturbance of its walls or with obstruction due to muscular spasm or hypertonicity of any portion of the canal distal to the cecum (frequent) or with obstruction from actually stenosing bands or membranes (pericolitic bands), or from acute angulation due to twisting on its own axis or the binding together by pericolitic adhesions of the two segments of an acutely bent colon (double barrelled colon, not rare), a condi-

tion of disease is created, overdistention and greater sagging of the unduly laden sac results, conditions of local infection develop, local pain is created, fecal stagnation and putrefaction follow and the symptoms of general auto-intoxication are added to the local picture. The frequent association of obstructive and infective conditions with *cecum mobile* is what renders it of surgical importance. The close association, both by contiguity and by lymph channels, of the right kidney with this portion of the bowel adds to this condition the special danger of perinephritic and nephritic infection.

ILLUSTRATIVE CASE.—*Cecum Mobile; Pericolitis; Perinephritis.*—Woman, aged thirty-nine years; has always been more or less constipated, frequent sick headaches, with vomiting; recent gradual loss of weight of thirty pounds. Four years ago she began to suffer from pain in the region of the right kidney; constant right lumbar tenderness, with occasional severe exacerbations over a period of one year, then freedom until one week ago, when an acute exacerbation was experienced. Urinary findings negative. Right kidney tender and prolapsed. Radiograph shows no calculus present. Posterior lumbar incision. Fatty capsule of kidney adherent by dense adhesions over entire surface of kidney. Entire mass of kidney and perinephric fat prolapsed below level of the last rib. Kidney tilted forward on its axis. Kidney freed from its adhesions by careful dissection and replaced in its normal position, so that its upper third was above the level of the last rib, where it was fixed by suitable sutures. Abdomen opened by anterior right rectus incision. A markedly distended and mobile cecum presented in the wound. The cecum was entirely free and the ascending colon was held only by a long slender mesocolon. The condition was typical of failure of the normal fixation of the colon on the right side. At the hepatic flexure there was a half-twist medially, sufficient to obstruct the free passage of the intestinal contents and menacing a possible volvulus. On the posterior lateral surface of the ascending colon there was a well-marked, pannus-like pericolitic membrane. There was well-marked congestion of the walls of the cecum and ascending colon. That portion of the intestine below the ileocecal valve, the cecum proper, formed a marked pouch, twice as large, at least, as normal. The appendix vermiformis was a long, thin, fibrous-like cord about six inches in length, attached by a very short mesoappendix lying posteriorly to the cecum. The appendix was removed. The large cecal pouch was surrounded by a purse-string suture inserted into the subperitoneal layer, by means of which the pouch was infolded up to the level of the ileocecal valve. When this was accomplished the cecum presented a normal appearance. The pericolitic film covering in the lateral wall was dissected off and a series of sutures at intervals of an inch were placed along this raw region, extending from opposite the ileocecal valve upward. These sutures were introduced into the parietal peritoneum at corresponding points and then tied, thus anchoring the ascending colon in its normal position and overcoming

the previous tendency to forward twist at the hepatic flexure. Gall-bladder and transverse colon normal. The result of these procedures was to give entire relief from the previously existing disabilities and to restore the patient to good health.

Diagnosis.—A diagnosis of a mobile and dilated cecum is suggested by the frequent occurrence of attacks of abdominal pain in the right lower quadrant of the abdomen, associated with gas distention of the colon in that region. Palpation and percussion of the region may elicit regional tenderness associated with gurgling and splashing sounds, and often the ballooned cecum is visible as a soft tumor. Constipation and auto-intoxication from the intestinal stasis is marked; the dilated, generally prolapsed segment of intestine is demonstrable by the *x*-ray after a bismuth meal or enema.

Treatment.—Minor degrees of the trouble, incident to non-fixation of the cecum, are amenable to medical treatment. Various degrees of intestinal stasis and its resultant local and general effects constitute the condition toward which medicinal and hygienic treatment is directed. Upon the failure of such treatment to relieve the condition, surgical intervention is indicated and may be instituted with every probability of positive and permanent benefit if all the associated conditions receive adequate attention. In many instances the attention of the surgeon is limited to the appendix vermiformis and its removal, often in a state of chronic inflammation, is alone done. While in many cases such removal of the appendix alone is followed by marked relief, in yet others no benefit follows, to the discredit of surgery and the surgeon, because of the failure to recognize and relieve by appropriate measures the other more essential pathological conditions present. The mobility of the cecum renders the colon prone to torsion at the hepatic flexure; stasis of the cecal contents results; dilatation and ptosis of the affected portion of the intestine follows; increased angulation at the hepatic flexure aggravates the tendency to stasis; infection transmitted through the intestinal wall excites a pericolitis of varying extent and degree which both lessens the peristaltic propulsive power of the affected intestinal segment and creates new sources of obstruction; the infection is transmitted in many instances to the right kidney and perinephric capsule, which has followed the colon in its descent toward the pelvis and a prolapsed and infected kidney is added to the problem.

The removal of the entire cecum and ascending and first part of the transverse colon, with anastomosis between the terminal end of the ileum and the transverse colon is the most radical of the procedures that have been resorted to for the relief of this class of cases. It has the merit of being thorough and complete in answering the indications, and to be free from remote secondary evils.[1] It requires, however, a high degree of technical skill upon the part of an operator to justify him in resorting to it, at least until the failure of less radical

[1] An extensive resection of the colon does not in itself exercise any deteriorating influence on the health of a patient. (Oppel, Ann. Surg., 1915, lx, 412.)

measures, and the severity of the symptoms attending the individual case, had made it imperative. (For technic of procedure, see page 186.) The primary operative indication in these cases is to remove obstruction and restore the normal facility of progress to the fecal current. This may be accomplished in most cases: (*a*) By the division of any pericolitic bands that constrict or angulate the ascending colon or hepatic flexure; (*b*) by anchoring to the postero-lateral parietes

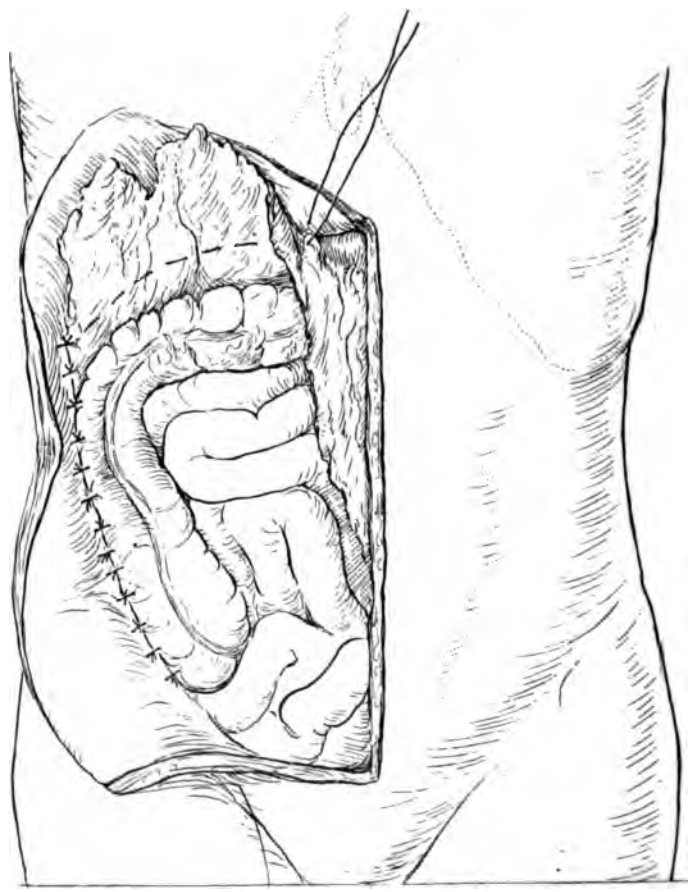


FIG. 20.—Schema of operation for anchoring the cecum and ascending colon and suspending the first half of the transverse colon by the great omentum. (Coffey.)

a too freely mobile cecum or ascending colon to prevent twisting and to keep it from prolapsing; (*c*) by reducing its size, if notably dilated, by longitudinal plication of the cecal and colonic wall or by turning any pouched portion into the cecal cavity by a purse-string suture; and, finally, by the removal of a chronically inflamed appendix.

The dictum of Coffey[1] is well taken that "surgical fixation of the

[1] Jour. Am. Med. Assn., 1915, lxv, 1811.

ascending colon should be extended so as to include also suspension of the first portion of the transverse colon by the omentum for the purpose of preventing harmful angulation at the hepatic flexure" (see Fig. 20).

ANOMALIES OF THE SIGMOID.

The sigmoid is of late development and varies greatly as to length. When it is redundant (a not infrequent condition and one associated with elongated meso), angulation and torsion are favored and a most critical surgical condition may result. A tendency to stasis of the contents is favored; constipation, auto-intoxication and local infections are frequent consequences. There is clinical evidence to support the conclusion that even such a condition as epilepsy may result from auto-intoxication occasioned by fecal stasis in a redundant sigmoid.

Diverticula.—Congenital defects in the muscularis of the colon is the frequent cause of the diverticula of the lower bowel which occasionally develop in later life. (See Diverticulitis.)

Megacolon.—Giant Colon.—Hirschsprung's Disease.—The various segments of the large intestine are at times found enormously dilated and hypertrophied. In most cases the condition is congenital even though its full development may not have attracted attention until adult life. In its lesser degrees, especially when limited segments of the colon are affected, relief may be hoped for from mechanical and dietetic measures. In the more aggravated conditions more radical measures, involving resection of more or less of the colon, are indicated.

Since the paper by Hirschsprung, in 1886, a voluminous literature has accumulated upon the subject of congenital hypertrophy of the colon.[1] The condition involves a dilatation and overgrowth of all the elements of the bowel, dependent upon the hypertrophy of its vascular and lymphatic systems. The disease, as a rule, manifests itself very early in life, although its development to the degree of causing serious symptoms is sometimes delayed until adult age. Habitual obstinate constipation is the cardinal symptom, as a result of which the abdominal distention becomes at times enormous. Fairly good general health may be maintained, notwithstanding the patient may go without evacuating the bowel for periods of some weeks. Violent peristalsis of the small bowel accompanied with loud borborygmi is often present. The condition leads ultimately to malnutrition; some intercurrent infection usually causes death, though peritonitis from perforation is not an uncommon result. It frequently terminates in volvulus (q. v.).

Treatment.—In a well-developed case of megacolon little result is to be expected from medical treatment. The surgical treatment to be recommended involves as its essential element resection of the redundant dilated loop. This may usually be most safely accomplished in two steps, the first step being a preliminary colostomy made in the healthy bowel above the dilated segment (Finney). After this the

[1] The student will find a complete bibliography of the subject by Finney in the Tr. Am. Surg. Assn., 1908, xxvi, 511.

necessary means (enemata) to relieve the dilated segment of its impacted contents are taken, and after a sufficient period of time has elapsed for the bowel to contract as much as possible from its dilated condition, the second operative step is taken, which consists in removing the whole of the affected portion of the colon, the closing of the free ends of the intestine by purse-string suture, and the making of a lateral anastomosis between the proximal and the distal segments. Later, at such period of time as may seem best, the primary colostomy wound is closed under local anesthesia.

Another method in dealing with a dilated colon was followed by Blake,[1] in a case in which, after opening the abdomen it was found that by reason of the long mesocolon the dilated sigmoid could be lifted for at least fifteen inches outside the abdomen; ligature and division was then done of such an extent of the mesocolon as would free the redundant portion of the sigmoid and yet permit easy approximation of the descending colon with the rectum. These were then sutured together along their mesenteric attachments, leaving the redundant freed loop of gut protruding at the lower angle of the wound, where it was held until the remainder of the abdominal wound had been closed. Each limb of this loop was then clamped separately and divided beyond the clamps with a cautery. Into the oral limb, proximal to the clamp, a tube was introduced and surrounded by a purse-string suture, making an artificial anus. Later the spur between the two intestinal barrels was cut out with an enterotribe, and the still remaining fistula was closed at a final operation.

Hubbard, in the case of a young woman, aged twenty-four years, with a megacolon giving typical symptoms, after exposing the bowel as the first step, divided the ileum just above the ileocecal valve and made a lateral anastomosis between the ileum and the upper rectum. He then divided the sigmoid just above this anastomosis, closed the distal end, and brought the proximal end out through the abdominal wound for drainage of the colon thus isolated. The abdominal incision was then closed. Six months later, during which time she had been having one to three normal movements daily through the artificial anus, the abdomen was again opened and the whole colon and cecum were removed, a little more than three feet in all. It is recorded that this operation was borne remarkedly well. The patient since that time, considers herself perfectly well. Her bowels are regulated by small doses of mineral oil.[2]

The one element worthy of remark in all these cases, as detailed, is that the surgeons dealt with them in two or more stages.

VOLVULUS.

The twist of a loop of bowel around its mesenterial attachments (axial rotation), until complete obstruction of the fecal current results, constitutes surgical volvulus.

[1] Ann. Surg., 1912, lv, 536.

[2] Ibid., 1916, lxiii, 349.

Volvulus is a comparatively rare cause of acute intestinal obstruction. From 5 to 7 per cent. may be accepted as the general average. (Treves,[1] 2.5 per cent.; McGlannan,[2] 8 per cent. of 257 cases of all kinds; Hodge,[3] 7 per cent. of 118 cases.)

It may occur in any portion of the intestinal canal; the small intestine, however, is less frequently the subject of this accident than is the large, and in the large intestine it is most frequently met with at the sigmoid region, although volvulus of the cecum is often met with. Gibson,[4] of 121 cases of volvulus of all varieties, found 36 of the small intestine; 58 of the sigmoid flexure, and 15 of other parts of the colon.

A normal bowel with a normal mesentery does not become the subject of volvulus. An abnormally elongated segment of mesentery; pre-existing adhesions producing fixation of some portion of the mesentery and supplying a fixed point around which excessive peristalsis may twist the mesentery; congenital defective rotation of the colon leaving the cecum floating in the left hypochondrium; a redundant and torpid sigmoid with an elongated meso and with a cavity filled with retained feces, these associated in varying degrees contribute to the development of a volvulus. Generally, but not always, there is a history of previous chronic constipation. Often inquiry will elicit the fact that previous attacks of transient obstruction have occurred (partial volvulus). Bowel distention is the second factor in the production of the final twist. Fermentation of retained intestinal contents supplies the distending medium; the distended bowel rises and turns in the direction of least resistance; the twist gradually becomes more pronounced until absolute occlusion of the bowel lumen is produced; secondary pathological changes ensue dependent upon the degree to which the twist interferes with the arterial supply or the venous return; the bowel wall quickly becomes so damaged by venous stasis, edema and hemorrhagic extravasations that sepsis is readily transmitted; necrosis, ulceration and perforation are terminal events. In lesser degrees of circulatory interference thrombosis of the mesenteric veins may occur and become the source of septic emboli that may determine infective disturbances in distant organs. The greater the distention the more fixed the twist becomes.

The bowel conditions which lead to volvulus, though primarily due to congenital defects, rarely reach their ultimate end in the accident in question until adult life, so that volvulus is rare during childhood and most common during middle adult life. Men are more frequently its subject than women.

Symptoms.—Colicky pain, ineffectual violent peristalsis, and absolute obstipation with abdominal distention are the primary cardinal symptoms. There may or may not have been previous constipation. In most cases a previous tendency to constipation has existed, and not infrequently a history of previous attacks of incomplete or transient

[1] Intestinal Obstruction, 1890, p. 141.
[2] Jour. Am. Med. Assn., 1915, lxiv, 1744.
[3] Ann. Surg., 1910, lii, 271.
[4] Ibid., 1899, xxx, 101.

obstruction can be elicited. Tenesmus with voiding of some mucus, possibly blood stained, is often a secondary symptom. The abdominal pain is continuous with intermittent paroxysms of severe cramps. Later vomiting may occur, but this is an inconstant symptom when the large bowel is the part involved. With the advent of peritonitis the abdominal wall becomes rigid and the tenderness more general. The distention of the abdomen, at first asymmetrical, owing to the meteorism of the affected loop only, increases and becomes general. Gangrene and perforation may be inferred when sudden increase of prostration and of septic intoxication occurs. Septic absorption is evidenced by the profound prostration which it produces. Leukocytosis accompanies these processes; the leukocytes may rise in number to 25,000 in a few hours.

Diagnosis.—The diagnosis is made on the association of obstinate constipation with early abdominal distention, at first asymmetrical, later becoming general. A history of previous constipated habit with transient obstructive attacks is suggestive and corroborative. When to the obstructive symptoms are added those of acute congestion, viz., pain, tenderness, increasing distention, with tenesmus and slight discharges of blood-stained mucus, the diagnosis of volvulus is practically established. Pain is an early symptom, paroxysmal at first, later constant with exacerbations. If enemata are administered the amount of fluid that can be injected will be limited by the capacity of the rectum to about one quart. It will be quickly ejected; after possibly at first some scybalous matter, no feces nor gas is brought away. The differentiation of volvulus from intussusception may come up for consideration. It involves first the question of age; volvulus, as a rule, is an affection of adults, intussusception of children; next the constipation of volvulus is absolute from the beginning; in intussusception a primary diarrhea is common, not infrequently it persists throughout the case, and rarely is the passage of all fecal matter arrested; the abdominal distention in volvulus is marked from the first; in intussusception meteorism is rare and on the contrary the abdomen is often distinctly sunken and an intra-abdominal tumor can be appreciated by palpation.

An early diagnosis is especially important that injurious measures of treatment may be refrained from, and that necessary treatment may be instituted before complications of peritonitis and gangrene may have developed to a degree that renders all treatment unavailing.

Prognosis.—The tendency of a twist once fully formed is inevitably from bad to worse. Spontaneous relief is not to be expected. The increasing distention of the affected loop tends to make the twist tighter and the early supervention of infection and gangrene is sure. Great general prostration soon develops, accompanied by the symptoms of peritonitis. If the condition is unrelieved the patient may survive some days although a more rapid progress to a fatal end is not uncommon.

Treatment.—The treatment involves as its very first and supreme indication the correction of the twist and this should be done before profound general prostration has developed or serious local infective and gangrenous changes have taken place. Opium should be given in quantities sufficient to relieve pain, arrest violent paroxysmal peristalsis and conserve the general strength. At the beginning of an attack a rectal tube may be passed and through it enemata given; if the twist is but partial this may be efficient to relieve it. If relief does not quickly follow such procedure it should not be persisted in. Cathartics are absolutely contra-indicated throughout.

As soon as the diagnosis of complete volvulus is made, the abdomen should be opened freely in the median line; the twist should be found and undone by simple manipulation if possible, after the division of any restraining bands or adhesions that may have formed. If the distention is so great as to render futile the efforts to reduce the volvulus by manipulation, the distended loop should be brought out on the surface of the abdomen and by trocar or incision enough of its contents removed to make its proper manipulation practicable and successful. When the twist has once been undone, then the further emptying of the bowel may be accomplished by injections through a rectal tube. The condition is now reduced to that of a megacolon (q. v.). It is important to remember that the redundant dilated loop, if left permanently, will seriously menace further disaster. Bloodgood[1] relates a case in which a volvulus of the sigmoid recurred partially or completely thirty-two times during sixteen years. Laparotomy was resorted to three times; at the last section the involved loop was resected and the case cured.

In a case coming under the writer's personal observation (Pilcher Hospital, Case 897) a woman, aged forty-six years, had twice before been operated upon for volvulus of the sigmoid without removing the dilated loop. Finally nine years after the first operation she was brought to the hospital on the third day of a third attack, *in extremis*, with a distention of the abdomen so enormous that the intra-abdominal pressure had so compressed the abdominal aorta that the iliac arterial circulation was completely cut off, and upon the distended abdominal wall no impression could be made by the firmest pressure. Through a very small incision in the abdominal wall the distended intestine was exposed; when this was punctured with the knife, an explosion like that of a punctured automobile tire followed. Immediately the pulse began to sink and very quickly faded out entirely in death. At autopsy the diagnosis of recurrent volvulus was confirmed. The gut was found completely rotated once on the mesial axis of its meso and was dilated to the extent of more than one foot in diameter. The dilatation was confined to the sigmoid loop alone.

If, after the twist has been undone and the bowel has been emptied,

[1] Ann. Surg., 1909, xlix, 163.

it be found that necrosis of more or less of the involved intestine has already occurred, or if the bowel damage falls short of full necrosis but the future viability of any part of it is uncertain, no option remains to the surgeon as to the course to pursue. The affected portion of gut must be brought out through the opening in the abdominal wall and secured in the lower angle of the wound, while the abdominal wound is closed around it by proper suturing.

Here it should be retained unopened for as long as the general condition of the patient will allow, forty-eight hours or more if possible, so that some degree of primary wound healing may be secured and recovery from the shock of the first operative procedure may be obtained. The later removal of the projecting portion may be done at any convenient moment thereafter and a temporary artificial anus be accepted as the best thing for the patient. Cases of volvulus usually, when brought to the operating table, are in threatened collapse, practically overwhelmed by septic poisoning, so that the operative procedures adopted must be as simple and rapid as possible. Subsequently if a happy outcome from the primary operative step is secured (always doubtful), the restoration of the continuity of the bowel and the abolition of the artificial anus may be accomplished—after sound health has been regained.

Angulation of the Sigmoid.—A condition of the sigmoid which must be considered as an incomplete volvulus has been described[1] under the term angulation of the sigmoid. In this state the intestine, without complete twist, is held bent upon itself so sharply as to obstruct the passage of the fecal current to a marked degree and in some cases completely. The tendency to strangulation of the blood supply of the involved loop, which forms so important an element in true volvulus, is, however, absent. Neither gangrene of the bowel nor profuse intraperitoneal serous effusion have been present in the cases reported, notwithstanding the obstruction to the passage of feces has been absolute for many days. Several elements evidently enter into the production of such an obstructive angulation: (1) An elongated mesosigmoid permitting an increased mobility of the sigmoid loop; (2) an exaggeration of the normal dilatability of the intestine with weak musculature and consequent defective peristalsis; (3) fecal stasis, usually obstinate, resulting in chronic distention of the colon with feces; (4) in some cases infection transmitted through the bowel wall has produced adhesions and thickening of the mesentery which serve as fixed points which determine angulation of the prolapsing weighted intestine. In this class of cases when the abdomen is opened and, in the search for the cause of the obstruction, the sigmoid is lifted up, the angulation at once is relieved and the retained contents of the sigmoid pass on immediately into the rectum. Further exploration may fail to reveal any other cause whatever for the obstruction. In such condition a happy result may also be expected in some

[1] Delatour: Ann. Surg., 1915, xlii, 678.

cases without abdominal section by the use of copious enemata while the hips are elevated highly (knee-chest position). The amount of fecal material voided after the angulation has been overcome by these means is sometimes astonishing in its quantity.

Diagnosis.—A provisional diagnosis of simple angulation may be hazarded in the presence of obstinate constipation with absence of symptoms characteristic of other causes of obstruction, such as neoplasm, bands or twist. It is a terminal development of conditions causing chronic fecal stasis. A history of previous chronic constipation may be usually elicited; at last ordinary cathartics fail altogether and a persistent obstipation is present; in some cases this has continued for two or three weeks before operative relief is secured. There is no tumor to be felt, no abdominal tenderness, but the distention is progressive, without change in the general health.

Vomiting is not a constant attendant. The uncertainty attending the diagnosis of intra-abdominal conditions is likely to be well illustrated in this class of cases. The same obstructive symptoms may be caused by a slowly contracting ring carcinoma, or by bands or adhesions of inflammatory origin which cripple the peristaltic power of the intestine. An absolute diagnosis can only be arrived at after exploratory section.

Treatment.—In the earlier course of such a case cathartics will already have been found useless. To persist in their administration is but to increase the suffering of the patient by the ineffectual painful peristalsis resulting. After a probable diagnosis of positive bowel obstruction has been reached, no cathartics should be employed until after the obstructing condition has been removed. Rectal enemata, aided by the knee-chest posture, may suffice to correct an angulation or partial twist, if such be the cause of the obstruction, and should be employed early. If such enemata, repeated twice or thrice, should fail to bring relief, the abdomen should be opened without further delay. But after the abdomen has been opened the surgeon should not prolong the exploration unduly at that time. What has been said in the preceding section as to the importance of a minimum amount of time and manipulation in the operative procedure applies to all cases of operation for relief of bowel obstruction, although the general condition of a patient in whom the obstruction is caused by a simple angulation is likely to be better than if a volvulus or other form of acute obstruction be present.

Unless the point of obstruction is quickly exposed and its nature is such as to admit of removal without much loss of time, or much handling or exposure of intestine (bands, adhesions, internal herniæ, twists, angulation, intussusception), the better course to pursue would be to do at once a colostomy or cecostomy, as the case may require, and to postpone to a later date all excisions and anastomoses required for the removal of a diseased segment and the restoration of the normal fecal channel.

INTUSSUSCEPTION.

Under certain conditions a segment of bowel may slip into the lumen of that part of the bowel continuous with it, as one portion of a telescope into an ensheathing tube. This is an *intussusception.* The swallowed portion of the bowel is termed the *intussusceptum;* the cover or casing is the *intussuscipiens;* the portion of the intussusceptum which constitutes the point of the advancing column is the *apex* and the point at which the entering bowel is engulfed by its sheath is the *neck* (see Fig. 21). The accident may occur along any part of the intestinal canal, but by far the most common point at which it begins is at the lower end of the ileum, the ileocecal valve forming the apex of the resulting intussusceptum. Systematic writers have made elaborate classification of intussusceptions accord-

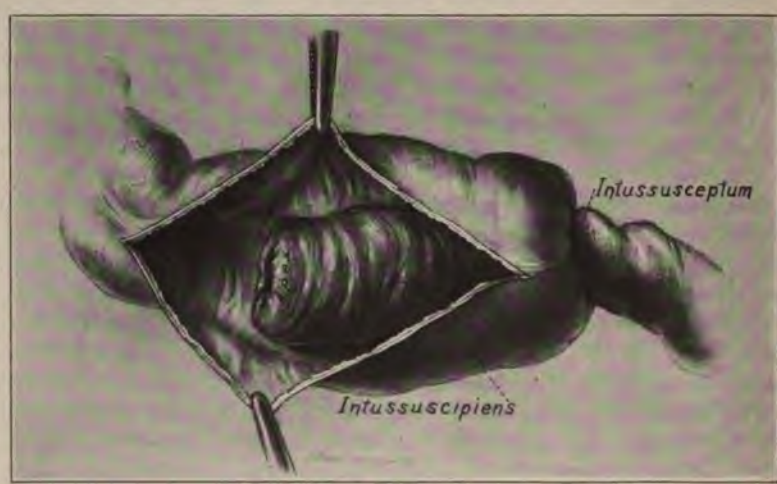


FIG. 21.—Intussusception.

ing to the location and extent of the bowel involved,[1] but the clinical value of these minute subdivisions is not great enough to make their consideration profitable here. The ileocecal and the colic varieties are practically one and have constituted more than three-fourths of all the cases that have come to surgical attention. To the frequency with which the cecum and ascending colon fail to become fully fixed in the right iliac region is to be ascribed the frequency with which this portion of the bowel becomes the seat of invagination. The mobility, capacity and flaccidity of the cecum, and the undue length of the mesocolon in these cases afford favorable conditions for the invaginations to occur. The same anatomical conditions favor the development of volvulus. Both conditions have been met with at the same time. It is quite reasonable to regard the invagination as starting in

[1] Corner: Ann. Surg., 1903, xxxviii, 690.

the physiological pouting of the ileocecal valve, which has become exaggerated on account of the laxity of the attachments of the intestine, until it is caught in the grip of the colonic peristalsis and forced onward.

A growth from the intestinal wall protruding into the lumen of the intestine has in many cases been the starting-point of an intussusception. Instances of sarcoma, carcinoma, myoadenoma, adenoma, even an inverted Meckel's diverticulum, have each been reported as the primary cause of an invagination. Double and triple intussusceptions, in which the sheath of the primary invagination becomes anew infolded, have been met with.

Intussusception is the most frequent cause of intestinal obstruction in young children. More than 50 per cent. of all cases occur before the age of ten years, and more than half of these occur during the first year of life.

The gravity of the conditions provoked by an intussusception is determined by the extent of the circulatory disturbance produced by the traction and compression of the vessels of the engaged portion of the mesentery. The mere invagination of the bowel need not lead of necessity either to strangulation of the involved part or to complete obstruction of the lumen of the intestine, but the usual sequence is venous stasis, exudation, infection, inflammation terminating in gangrene; blood is extravasated into the wall of the strangulated gut, and blood oozes from the mucous surfaces. Adhesions between the apposing serous surfaces form, though not always sufficiently to prevent diffuse septic peritonitis spreading from the gangrenous perforation. In the more acute cases the condition advances rapidly to a fatal issue. In the less intense degrees of strangulation serous adhesions may limit the infection, the primary swelling may subside so that the bowel permits feces to pass with some freedom, and ultimately the entire intussusceptum may slough and be expelled, and spontaneous recovery follow. This process, however, may be interrupted at any period of its course by perforative accidents and a quickly fatal termination. Among children the more acute forms prevail; among adults, the chronic.

Symptoms and Course.—ACUTE CASES.—The patient is most often a nursling and in previous good health who is attacked by sudden severe *abdominal pain*, causing piteous outcries; the pains are paroxysmal in character, significant of irregular violent peristalsis, or if constant are marked by exacerbations; there may be periods of relief alternating with the periods of colicky spasm. The pinched face, by its pallor and sunken eyes, shows general shock; the pulse is rapid and weak, and the skin is covered with cold sweat. The temperature is subnormal, followed after a few hours by a rise in temperature due to congestion and sepsis. The abdomen is not tender to palpation at first and may be relaxed in the intervals between the paroxysms of pain. With the later supervention of local congestion and of peritonitis tenderness, muscular rigidity and distention develop.

After a few hours these primary acute symptoms may ameliorate for a time owing to the anesthesia of local necrosis. This betterment is but a temporary lull which should not deceive as to the seriousness of the condition. The due appearance of the symptoms of gangrene and septic peritonitis will not be long delayed.

Vomiting.—Vomiting is rarely absent in acute intussusception, but it is not so early nor so constant as in cases of band or hernial strangulation. In chronic cases it may be much delayed or absent altogether. Rarely does it become feculent owing to the low position in the intestinal canal at which the invagination usually occurs, and to the continued perviousness of the intestinal canal.

Evacuation of Bloody Mucus.—Evacuation of bloody mucus almost invariably follows the formation of an intussusception, being the product of the congestion and squeezing of the intussusceptum. A bloody mucous stool suddenly passed from a healthy baby is almost pathognomonic of intussusception. The attack begins with diarrhea and tenesmus, the discharge at first being feculent and later only blood and mucus. The nearer the anal outlet the intussusceptum descends the more marked is the tenesmus.

Abdominal Tumor.—The invaginated mass of intestine and mesentery, swollen by the products of congestion, forms a sausage-shaped tumor which in many cases may be felt through the abdominal wall at some point in the line of the colon, as long as the abdomen remains relaxed. This tumor is not tender at first but becomes so as time advances. It is most frequently found on the left side in the descending colon. Later in the history of the case, if a long area of intestine has been telescoped, the tumor may be felt high in the rectum by a finger introduced through the anus. In occasional instances the intussuscepted bowel ultimately protrudes through the anus, simulating a prolapse of the rectum.

Subacute and Chronic Cases.—Subacute and chronic cases are those in which the engulfed tissues are less closely constricted by the neck of the intussuscipiens; absolute strangulation does not occur, or is a late and partial occurrence; a chronic train of symptoms is produced; the lumen of the bowel is never absolutely occluded, or, if so, is early restored by the subsidence of the primary swelling of the intussusceptum through the mucosanguineous flux; the two cylinders become fused together by the adhesion of their peritoneal surfaces. The partial obstruction may ultimately be relieved by the separation of the invaginated segment of intestine as a slough, or after months of suffering may terminate fatally from perforation and peritonitis, or by exhaustion from diarrhea and malnutrition.

Diagnosis.—Early diagnosis is of the highest importance, for the earlier the efforts are made for replacement of the telescoped bowel the greater the probability of a successful result. Sudden and severe pain in recurring paroxysms, as indicated by the cries of the infant; with vomiting and shock, followed by the passing of bloody-mucus stools, constitute an assemblage of symptoms that is pathognomonic

and calls for immediate radical treatment. If with these symptoms palpation of the abdomen reveals the presence of a tumor in the line of the colon, or a finger passed into the rectum feels a tumor filling its cavity, the diagnosis is confirmed.

Treatment.—Treatment to be effectual must be instituted before the intervention of such inflammatory and gangrenous changes as render reduction impossible and necessitate major surgical procedures of uncertain result. Edematous swelling of the intussusceptum and the formation of adhesions are sure to have become extensive by the close of the second day of the condition. In infants and young children especially, the supervention of edema and adhesions is early and the development of lethal conditions progresses rapidly. Three indications for treatment are to be kept in mind: (1) The immediate relief of pain; (2) the complete reduction of the invagination; (3) the prevention of future recurrence of the accident.

1. Opium should be given at once in sufficient amount to relieve pain and control peristalsis, while due consideration should be given to any apparent relief due to its soothing influence lest false judgment as to the real condition should be created.

2. Reduction of the invagination by distention of the colon with air or water may be successful if resorted to before the formation of adhesions and great swelling of the intussusceptum has taken place. The more acute the symptoms the greater the importance of immediate attempts at reduction. Little hope of success attends such attempts after twenty-four hours have passed since the invagination occurred. For distending the colon and pushing back the invaginated bowel enemata of warm water and insufflations with air have been practised. Of the two agents the air insufflation is to be preferred. The pressure exercised by it is more uniform and elastic, and its amount can be better gauged by the hand manipulating the rubber bulb by which the air is forced into the intestinal lumen. If water is chosen with which to distend the bowel, it should be introduced by gravity from a douche bag, held at a height of from five to six feet only above the abdomen of the child. Each two and one-half feet of height represents a pressure of one pound to the square inch. The possibility of the bowel wall having been weakened by edema and necrosis is ever to be kept in mind and the utmost gentleness used in all manipulations. As a preliminary to any attempt at distending the colon a general anesthetic should be administered and the child kept under its influence during the procedure.

When once adhesions have formed enemata or insufflation will be quite useless. Should the intussusceptum have become gangrenous or softened, the force of an enema or of extreme air distention may cause rupture and permit the intestinal contents to escape into the peritoneal cavity. A more frequent attendant upon these efforts at reposition is a failure to fully reduce the invagination, while the small remaining intussuscepted segment does not make a mass of sufficient size to be appreciated by palpation, so that a surgeon is misled into

an erroneous conclusion that the difficulty has been wholly overcome. A speedy recurrence of the full invagination is sure to follow. Again it will be realized that even if full reposition has been secured by the colonic distention that has been resorted to, the anatomical conditions which have favored the production of the invagination in the first place still remain uncorrected to favor the repetition of an invagination at a future day. The best interests of a patient suffering from intussusception cannot, therefore, be fully met without opening the abdominal cavity and securing both visual and tactile control of the involved intestine. In this spirit all the arrangements for treatment should be directed as soon as the diagnosis has been made. All the resources of a hospital are desirable and should be obtained if possible.

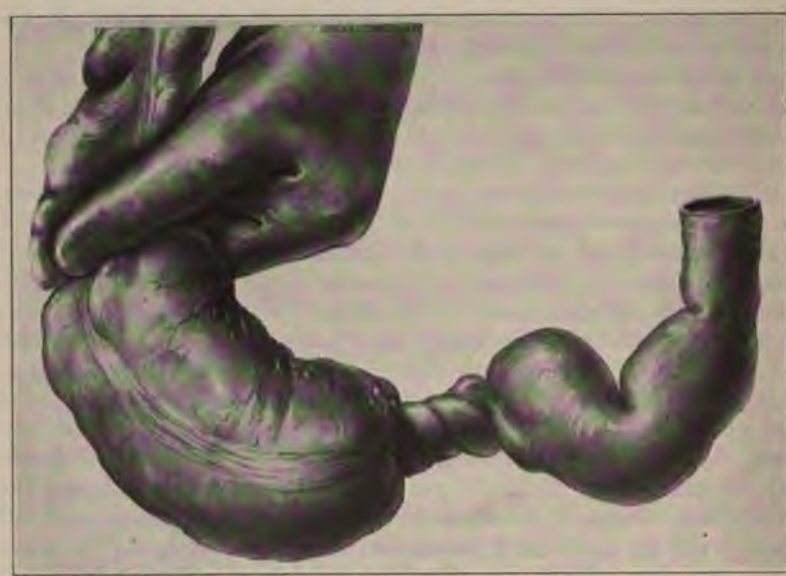


FIG. 22.—Manipulation for reduction of intussusception.

The patient should be anesthetized, and as soon as the dilatation of the colon by water or air is ready to be proceeded with, the abdomen should be opened and the disinvagination of the swallowed intestine should be aided by gentle manipulation of the colon by the fingers of the surgeon. The lower limit of the invagination is sought for by exploration beginning in the right iliac fossa and thence passing along the line of the colon to the termination of the intestinal tumor. The pressing back of the engulfed intestine is best helped by gentle squeezing manipulation pressing the apex of the intussusceptum upward (see Fig. 22). Great gentleness should be employed in this work to avoid lacerating the peritoneum. When once the reduction is started it proceeds rapidly until the popping out of the appendix shows that the colonic part is entirely unrolled. Special care is now

required to make sure that all enteric pouting is also entirely overcome and that full and complete reduction has been secured.

Throughout the procedures which have been described every possible precaution should be taken to guard against the shock to which the age of most of these patients renders them liable. Distention of the stomach, if present, should be relieved by the introduction of a stomach-tube. The infant should be wrapped in warm dry blankets and the exposure of the intestine should be made as little as is consistent with rapid and intelligent manipulation. The abdominal incision must be sufficiently ample to admit of the ready introduction and free movement of the fingers; if manipulation of the tumor-enclosing colon is not facile while the colon remains within the abdominal cavity, the portion enclosing the tumor should be drawn outside the belly and isolated by hot moist packs; that part containing the swollen apex of the intussusceptum should be compressed gently, but firmly and continuously until manifest diminution of the edema of the apex has been accomplished. If the condition of the gut is good and the fibrinous adhesions are soft and of little extent gentle traction may be made upon the entering portion, while the manipulations at the apex are proceeding. After reduction has been happily accomplished the bowel should be examined for the possible presence of any polypus or inverted diverticulum, which could have been the primary excitor of the invagination. If such is found present, the intestine must be opened and the polypus or diverticulum removed. The final step should now be fixation by suture of the mobile cecum and ascending colon in their normal site to prevent recurrence of the invagination. For the technic of this step see the section on colono-parietal fixation, p. 173.

Irreducible Intussusception.—Efforts at disinvagination may be unsuccessful either because of the firmness and extent of the adhesions already formed, or the extreme degree of swelling and friability of the intussusceptum, or the presence already of gangrenous changes. Sargent, quoted by Moynihan,[1] gives the following tabulated statement as to the relation between the period of intervention and development of irreducible conditions and the ultimate mortality in cases operated upon at St. Thomas's Hospital, London:

Operations.	Day.	Percentages of tumors reducible.	Character of operation.	Mortality, per cent.
35	First	94	2 resections	37
36	Second	83	3 resections 3 artificial anus	39
33	Third	61	9 resections 4 artificial anus	61
15	Fourth	40	9 resections	67

The fifth and sixth days showed respectively a mortality of 73 and 75 per cent.

[1] Abdominal Operations, ii, 124.

An irreducible invagination may not be gangrenous, nor be threatened by gangrene. Such a condition is more likely to be met with in adults as a chronic condition. In such a case a short circuiting operation would be feasible by which the healthy intestine proximal to the intussusceptum should be made to open into the intestine distal by a lateral anastomosis, while the intussusceptum itself is ignored.

An *irreducible gangrenous* intussusception may be dealt with in one of three ways: (*a*) The whole mass may be excised and an anastomosis be done. The technic does not differ from that of intestinal resections and anastomoses for other conditions. As the subject for most of such operations is an infant, the prognosis is very grave on account of the prolongation of operative manipulation and peritoneal exposure and anesthesia in the presence of great initial depression. On the other hand, the more rapidly accomplished (*b*) artificial anus leaves a condition little suited to the conditions of childhood; the small intestine is involved in the anus; the liquid fecal discharge is continuous, and marasmus from malnutrition is progressive.

In place of either (*a*) or (*b*) there remains to the surgeon the procedure of Barker (*c*) which is described by Moynihan[1] as follows: "At the point at which the intussuscipiens receives the intussusceptum, the two portions of the bowel are at once united by a continuous circular suture of fine silk, taking up the serous and muscular coats of each, and carried on to the mesentery. A longitudinal incision is then made for about two inches through all the coats of the intussuscipiens on its free margin. This gives access to the sausage-like intussusceptum within. The latter is then drawn out through this incision and is cut across close to its upper end, or, if too long to be first drawn out, it may be cut across *in situ*. A few stout silk sutures are passed through all the walls of the stump as the mass is gradually cut off and are tied tightly so as to keep the serous surfaces in contact and control all bleeding from the vessels entering it at its mesenteric attachment. The stump is dropped back through the incision into the lumen of the intussuscipiens, then the longitudinal incision is closed by a continuous suture."

COLONOPTOSIS.

It is a natural advance from the consideration of the positive obstructions of the bowel caused by twists and angulations and intussusceptions to the impairments of peristalsis due to ptosis of the colon by which angulations of a lesser degree are created and partial fecal stasis is occasioned. A lessened peristaltic activity is a normal characteristic of the large bowel whose function seems to be more one of convenience than necessity. There are certain definite normal anatomic conditions which tend to impede the rapidity of the onward

[1] Abdominal Operations, ii, 119.

movements of feces in the colon. These are the hepatic and the splenic flexures and the convolutions of the sigmoid. The normal relations of the cecum and colon are well shown in Fig. 23 reproduced from a skiagraph of a healthy adult. This colon is in a state of tonic contraction upon the distending medium that has been thrown into it. In a state of relaxation it will fall into folds that in the upright position hang like a festoon between the hepatic and splenic flexures and the level of the transverse colon will be below the umbilicus.

FIG. 23.—The normal colon constructed from a skiagraph taken twelve hours after the ingestion of bismuth emulsion, supplemented by an enema of the same given ten minutes before the photograph was made. Note the position of the cecum in the concavity of the iliac fossa; note the oblique manner in which the transverse colon crosses the abdomen above the level of the umbilicus upward to the splenocostal region on the left; note the sharp angle at the splenic flexure which is typical; note the crumpled folds of the sigmoid flexure in the superior pelvic strait. The position of the umbilicus is indicated by the circle.

By reason of the rather firm attachments to the parietes of the two flexures of the colon, these flexures are comparatively fixed points, and when for any reason that part of the colon between these two points is made to habitually descend into the pelvis the angles of these two flexures are accentuated and the onflow of feces is rendered more difficult. It is, however, not so much the lower level at which the colon is lying that determines the stasis as it is the greater acuteness and fixity of the angles that this low position causes that is the source

FIG. 24.—Colonoptosis with exaggerated flexion at the hepatic and splenic clinical symptoms, chronic fecal stasis and marked auto-intoxication.

FIG. 25.—Showing associated ptosis of stomach and colon.

of the trouble. This is well shown in Fig. 24. Such descent of the colon naturally carries down with it the stomach, so that the final condition to be considered is one of gastro-colonoptosis (Fig. 25). The conditions in the cecum and colon attending fecal material retained are favorable for bacterial development and for the formation of the complex and varied products of bacterial life processes. When such fecal retention is unduly prolonged it is the absorption of these products into the general circulation that produces the phenomena that are recognized as the symptoms of the toxemia of intestinal stasis, which toxemia in many cases is sufficiently grave and persistent to call for the addition of operative measures to correct the ptosis when means of a more general character for their relief have not been efficient. The systemic reaction produced by this self-poisoning from retained intestinal contents is characterized by mental depression, general malaise, headaches, loss of appetite and sluggishness of the peripheral capillary circulation. Many cases which have been termed neurasthenia, hysteria, gastralgia, etc., are but the result of self-poisoning from retained intestinal contents. Chronic enteritis, chronic inflammatory conditions of the appendix, the gall-bladder and the kidneys may have as their primary cause sepsis of intestinal origin. The condition, therefore, of colonoptosis with its resultant fecal stasis is an important and far-reaching one for the control and relief of which the resources both of internal medicine and of operative surgical effort will be required.

In the cecum occur most frequently the conditions which accentuate the results of fecal stasis. When it remains unduly mobile, its prolapse is certain and a train of irritative and infective results is established. Acute angulation of or torsion at the hepatic flexure leads to dilatation of the intestine between the ileocecal valve and the hepatic flexure; conditions favorable to the transmission of a low grade infection through the intestinal walls are created, which result in the production of pericolic adhesions and bands that still further cripple the colonic peristalsis. This condition in its full development is shown in Figs. 26 and 27. Through the lymphatic connections between the cecum and ascending colon and the right kidney infection of that kidney and of its perirenal space so readily and frequently occurs that the possibility of such renal infection lends additional gravity to the colonic condition. A chronic inflammation of the appendix vermiformis is an extremely frequent complication of colonic stasis, which it aggravates and perpetuates. Gall-bladder infection and duodenal and gastric ulcer are so frequently found in connection with colonic stasis as to make very probable that there is a causal relation of the latter to the former.

Colonoptosis occurs most frequently among women, in whom the habits of life, methods of dress and the special muscular relaxations following child-bearing, conduce to its production. In the support of the various organs of the abdomen in their proper positions, the uniform compression exercised by the abdominal muscles, aided by

atmospheric pressure, is the chief factor. Individuals with thin relaxed feeble muscles present favorable conditions for defective visceral support. That type of woman in which, in addition, the upper abdomen is narrow presents the most favorable conditions for

FIG. 26.—Acute angulation of hepatic flexure of colon; cecal stasis; pericolic membrane binding ascending colon and first portion of transverse colon together. Sketch made at time of operation.

the downward crowding of the colon and stomach. By corset pressure the tendency to descent is still further accentuated. In certain young nulliparous women, and in some young feeble-muscled men without the help of a corset, this lack of support may be sufficient to induce

a habitual descent of the viscera. The liver, the kidneys, the stomach prolapse, and carry the colon with them. The constipation that is caused by the malposition of the colon adds its load to the preceding prolapse-producing agencies, and aggravates the ptosis. If, as is

FIG. 27.—Acute angulation of hepatic flexure of colon; cecal stasis, pericolic membrane binding ascending colon and the first portion of tranverse colon together. Sketch made at time of operation.

the case in many of this class of individuals, there is a redundant colon, the condition is still further accentuated and rendered difficult of remedy. In the maternal colonoptosis of multiparous women the colon is the chief displaced organ and often is the only one which

requires the attention of the surgeon. The gastrocolic omentum and the mesocolon have become elongated as the loaded transverse colon, deprived of the normal muscular support of a firm abdominal wall, tugs at its ligamentous supports and gradually sinks toward the pelvis. Fecal stasis to a marked degree results and the usual train of symptoms indicative of intestinal auto-intoxication follow.

Symptoms.—The symptoms of colonoptosis are indefinite. They consist primarily of the constipation and the degree of auto-intoxication that has occurred. These will vary greatly in different patients with the same amount of prolapse, differences being dependent upon the varying ability of the colonic musculature to propel its contents onward, and the existence of pericolitic and inflammatory complications. The very great frequency with which a chronic appendicitis and a moderate pericolitis are present as complications will add in many cases the special symptoms of those conditions in the right iliac fossa. The accompanying gastroptosis will also add its symptoms and render the condition still more complex. The frequency with which these various conditions are associated should always be kept in mind in the interpretation of symptoms and in determining the means and scope of treatment to be adopted. The imperfect and unsatisfactory results which are often met with following operative attempts to relieve some of these conditions are doubtless often due to the fact that only a part of the lesions requiring attention have been adequately treated.

Diagnosis.—The final and convincing diagnosis of ptosis is to be obtained by a skiagraph of the colon filled with bismuth emulsion by enema. Such radiographic examination is of great importance both as a diagnostic method and as a means of controlling the results of treatment. It is important that the skiagraph should be taken with the patient in the standing position, in order to know the real extent of the prolapse of which the intestine is the subject. In the diagnosis of large intestine conditions both the opaque meal and opaque enema should be resorted to. The filling of the colon with an opaque enema is of the highest importance. This should be checked by observations of an opaque meal, the skiagraphs being taken six and twenty-four hours after the administration of the meal. At the end of six hours normally the column of bismuth will have reached the splenic flexure while its proximal end will be still in the terminal ileum. At the end of twenty-four hours there should be little of the bismuth left in the colon; wide variations to these limits, however, may normally exist. The usual bismuth emulsion used for stomach examinations is to be employed.

For enemata barium sulphate will be less expensive than bismuth and for most examinations will prove quite satisfactory. Its shadow, however, is less dense than is that of the bismuth and in conditions in which sharp definition is desired, as in looking for diverticula, the bismuth is preferable. For the barium enema six ounces of the "prepared" barium sulphate should be stirred into a quart of slightly

warmed buttermilk; this mixture is then allowed to flow into the rectum very slowly, with frequent interruptions, through a soft rectal tube, the tip of which has been inserted between two and three inches beyond the sphincter, the patient lying on the left side. The whole colon fills with the enema within a few minutes, clear to the ileocecal valve.

Treatment.—From the preceding statements it is obvious that while prolapse of the colon, whenever present, is always an important element of the disability from which a patient may suffer and requires specific attention, it is yet but one of various associated conditions, all of which have to be taken into consideration in carrying out therapeutic measures, if full relief is to be secured. The study of any individual case will require careful determination of the status of all the abdominal organs. Prolapse of the liver and stomach, if present to a marked degree will require special correction by hepatopexy and gastropexy (*e. g.*, the method of Rovsing). A more moderate degree of prolapse of the stomach may be remedied sufficiently by the omental hammock swing of Coffey, to be described in a subsequent paragraph. A relaxed baggy abdominal wall should be reinforced by an abdominal support (Figs. 28 and 29). Such abdominal support must press upon the hypogastrium from below upward, broadly and firmly. A suitable lumbar pad should be the base from which should pass forward adjustable belting or straps that should control a firm, broad pelotte above the pubis in front. The belt should be adjusted while the patient is in the recumbent position, before rising in the morning, while the organs are most nearly in their normal position.

Massage and such exercises as tend to develop the abdominal muscles should be employed, with such general hygiene as shall promote the body nutrition as a whole.

In most patients occasional tendencies to stasis and intestinal fermentation will require from time to time the use of laxatives, enemata and intestinal antiseptics to control them. The various preparations of paraffin oil, of cascara sagrada, of phenolphthalein, the compound licorice powder, in some instances the intravenous injection of hormonal, will all find a place in the medicinal measures to be used both before and after any operation for the relief of stasis due to prolapse of the colon. As to diet the proteids should be taken in minimum quantity, and the carbohydrates should be more largely used. Green vegetables and salads should be taken freely to increase the bulk of the stools, and fats for intestinal lubrication. Agar-agar and the mineral oils, which form the bulk of various laxative preparations in common use, have their value in supplying bulk and lubrication to the stools. Preparations of lactic acid bacilli have some value as intestinal antiseptics. The condition of the *appendix vermiformis* is of the first importance to be ascertained in cases of colonoptosis. In a large proportion of them it will be found to be chronically inflamed and as a result the center of irritative disturbances that seriously cripple colonic peristalsis. The cecum and ascending

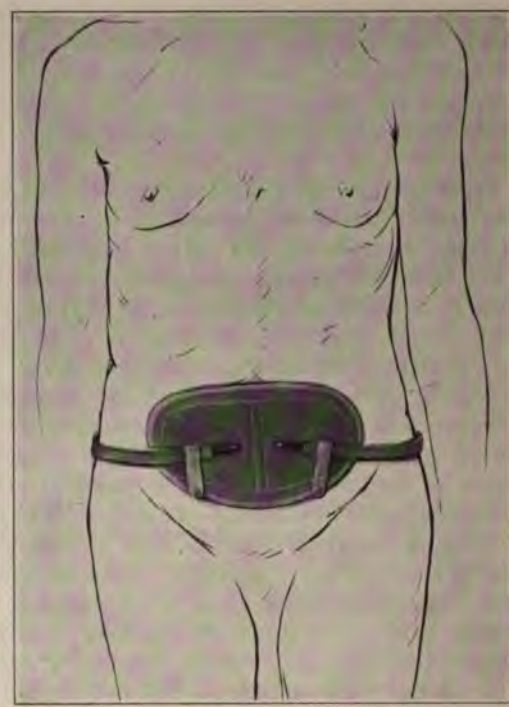


FIG. 28—Abdominal pad for support in cases of gastro- and enteroptosis. Ante view.

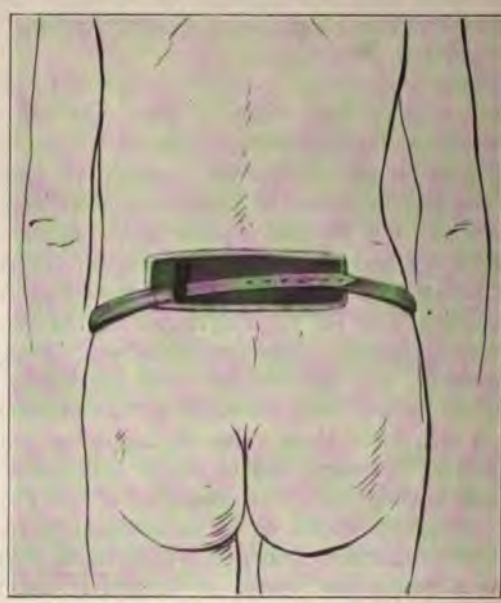


FIG. 29.—The lumbar pad from which spring the straps or springs that control abdominal pad shown in Fig. 28.

colon are especially the subjects of this disturbance. In many cases a degree of colitis and pericolitis coëxist with the appendicular congestion, and in certain of these will be found to have developed pericolitic adhesions, bands and films that mechanically cripple the peristalsis of the ascending colon. The appendix will often be found to be buried beneath these new-formed adhesion bands, which in some cases extend to the terminal portion of the ileum and so drag

FIG. 30.—Terminal portion of the ileum. The appendix and cecum bound together by strong membraniform film. Note the dense band binding the ileum to the brim of the pelvis.

down and deform that portion of the intestine as to interfere with the free passing of the contents of the ileum through the ileocecal opening ("Lane's kink") (Figs. 30 and 31). The exposure of the appendix, its removal if found diseased, and the division of all films and bands that might cripple the terminal ileum, the cecum or the ascending colon should be the first step in any operative attempt to relieve a ptosis of the colon.

The operative means available for the elevation of the colon suffi-

ciently to overcome obstructive angulations in its course, or to divert the fecal current around them by a shorter circuit are now to be considered.

FIG. 31.—Pericolitic films binding together the appendix, cecum and ileum. Note the strong band extending from the ileum to the iliac fossa and the films restricting the mobility of the cecum and the ascending colon.

Beginning at the cecum these may include: (*a*) The division of a parieto-ileocecal band, kinking the terminal ileum or dragging upon the head of the cecum (common); (*b*) the division of parieto-colonic bands (pericolitic films) that constrict the ascending colon, or accentuate the hepatic flexure by upward tension or by binding the ascending and first part of the transverse colon together at a sharp angle; (*c*)

the anchoring of a free cecum and a loosely held ascending colon by suturing them to the right posterior parietes; (*d*) as a last resort, in cases of right-sided ptosis and angulation, after the failure of less radical measures, the excision of the cecum, ascending colon and first part of the transverse colon, and the insertion of the terminal ileum into the transverse colon; (*e*) when the ptosis is chiefly a midline condition, often a part of a general visceroptosis, the sagging of the upper abdominal viscera, *i. e.*, liver and stomach, must first be overcome by proper fixation methods, after which the transverse colon may be fixed to the anterior abdominal wall above the umbilicus by a transverse row of sutures that attach the gastrocolic and great omentum to the parietal peritoneum (Coffey's hammock method); (*f*) in cases in which after the adoption of these measures to elevate the transverse colon the angle at the splenic flexure continues the stasis by its acuteness, an anastomosis between the ascending segment of the transverse and the descending colon may be made (colocolostomy of Lobingier) (Figs. 32 and 33); (*g*) in the event of failure of the previous named methods to relieve the stasis, or in the presence of a degree of ptosis, angulation or constriction so extensive as to render improbable a successful outcome to any measure of a less radical character as above enumerated, the entire colon may be resected and an anastomosis made between the terminal ileum and the terminal segment of the sigmoid flexure or the upper portion of the rectum (Lane).

The technic of colonoparietal fixation and of partial or complete colectomy is as follows:

Technic of Colonoparietal Fixation for Relief of Midline Ptosis.[1]—Incision in the median line from xiphoid cartilage to below the umbilicus; after the abdomen is opened the viscera should be examined and the various operative steps determined. In the more advanced cases, in which there is ptosis of the liver and stomach with contraction of the upper abdomen, the first step should be the plication of the falciform ligament by suitable sutures of chromicized catgut, which finally are secured through the parietal peritoneum to the subperitoneal fascia behind the ensiform process; next, the liver having been replaced under the dome of the diaphragm, its anterior edges should be fastened to the parietal peritoneum covering the diaphragm anteriorly by a number of quilt sutures to the right and the left of the falciform ligament. These sutures also should include the subperitoneal fascia, from three to five being placed on either side. Then the anterior wall of the stomach should be sutured to the anterior parietes, after the manner of Rovsing. In conditions in which the ptosis of the stomach is not marked this step may be omitted, and the support of the stomach may be trusted to the omental hammock next to be created.

The third step for reposition of colon and suturing of omentum to

[1] Coffey: Surg., Gynec. and Obst., 1912, xv, 411.

the abdominal wall: The incision is held wide open by retract and the parietal peritoneum at the edge of the wound is pulled

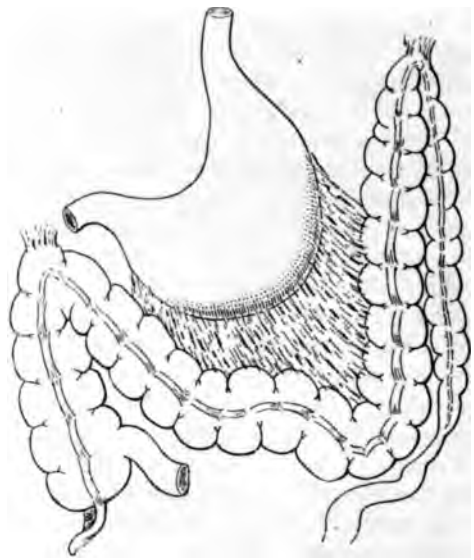


FIG. 32.—Showing dilated ascending and transverse colon and sharp angul at the splenic flexure. The descending colon is one-third the diameter of the t verse and is in spastic contraction at its junction with the sigmoid.

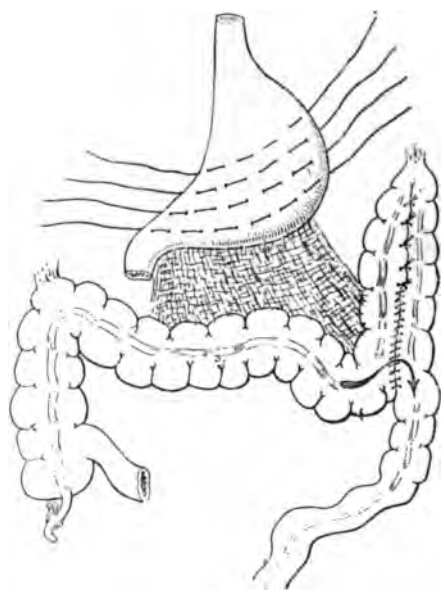


FIG. 33.—Suspension of the stomach, plication of the gastrocolic ligament an colocolostomy between the ascending segment of the transverse and the descending co reëstablishes the colon current and relieves stasis.

as far as possible, especially on the left side. A needle, armed with linen or chromicized catgut, is passed through a good bite of the parietal peritoneum, as far toward the left as the suture can be conveniently placed with a needle-holder, on a line crossing midway between the ensiform cartilage and the umbilicus. The needle is then passed through a bite of the gastrocolic omentum at a point corresponding to the parietal insertion of the suture, and one and one-half inches below the lower border of the stomach. The same suture is passed through a second bite so as to include all the layers of the omentum just below the colon. The two ends of the suture are

FIG. 34.—Same patient as in Fig. 24 after elevation of colon and fixation by suture; clinical result relief of intestinal stasis and marked improvement in general health.

now tied. The next suture is placed about one-half inch nearer the median line. After three or four sutures are thus placed on the left side, a similar row of sutures should be placed on the right side, and this process is continued until the line of sutures is completed to the edge of the parietal peritoneum, and to a point near the center of the omentum. Care is to be taken to avoid constriction of the bloodvessels of the omentum, and also to avoid twisting of the omentum. The abdominal wound is now closed by layer sutures. The peritoneal suture, as it crosses the line where the omentum is being attached to the abdominal wall, takes the omentum in its bite and thus finishes the hammock (Figs. 34 and 35). In cases of marked

narrowing of the upper abdomen, the upper abdomen should be widened by a plastic operation upon the anterior sheath of the rectus muscles.

In order to overcome the pendulousness of the lower abdomen, when its degree is very great, a plastic lessening of the area of the external oblique muscle may be done by splitting the aponeurosis of the external oblique muscle, parallel to its fibers, in such a manner as to converge with a like split on the opposite side, at a point just above the symphysis. The flaps having been separated from the internal oblique muscle should be imbricated one above the other, and secured by suitable quilt sutures.[1]

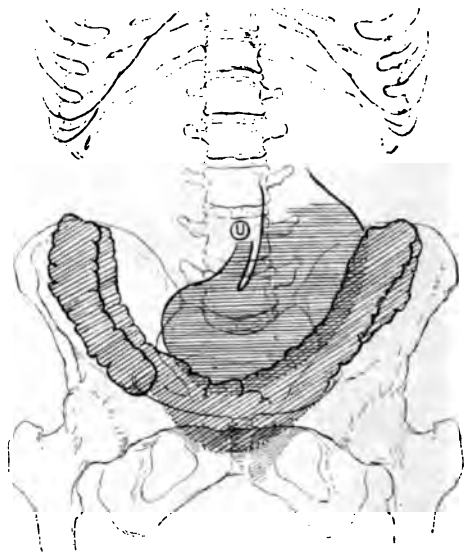


FIG. 35.—Gastrocolonoptosis: Composite picture constructed from skiagrams of the bismuth-filled stomach, and of the colon distended with a bismuth enema; the elongated cardia permits the pylorus and lesser curvature of the stomach to fall to a level, two inches below that of the umbilicus, the stomach itself is dilated, the curvatures of the colon have fallen to the level of the iliac crests, and the top of the transverse colon fills the pelvic opening.

ILLUSTRATIVE CASE.— *Hepato-gastro-coloptosis; Retroversion and Prolapse of Uterus; Chronic Appendicitis* (Pilcher Hospital No. 851). —Woman, aged twenty-seven years, but looking much older. For four and one-half years, has suffered from increasing constipation; typical history of auto-intoxication and intestinal stasis, coupled with pelvic symptoms, due to prolapse of uterus and cystocele. Complains also of continuous upper abdominal discomfort, food pain, traction pains on left side and upper abdomen; is a chronic invalid.

Examination demonstrated liver markedly prolapsed to the level

[1] Coffey: Surg., Gynec. and Obst., 1912, xv, 404, Fig. 78.

of the umbilicus, and stomach dilated and prolapsed anteriorly below the umbilicus. (See Fig. 35, showing position of stomach and colon.)

Hepatic and splenic flexures in normal relation but lying on a level with the crests of the ilia; transverse colon prolapsed into pelvis; obstruction of ileocecal junction. None of the bismuth meal had passed that point at the end of eight hours. The uterus was in retroversion and prolapsed to the introitus.

Operation.—Hepatopexy; gastropexy; colon suspension; appendectomy; hysteropexy; March 12, 1915. Right rectus incision from tip of ninth rib to below umbilicus. The appendix was first sought, found bound down by adhesions behind the cecum. It was enucleated and removed. Second step, liver was sutured into place by attaching it for three inches along the anterior edge of the right lobe to the insertion of the diaphragm at the free border of the ribs. Third, the round ligament of the liver was plicated and attached high up in the dome of the abdomen, behind the xiphoid appendix, sutures of chromic gut being used. Fourth, the transverse colon was attached to the greater curvature of the stomach by two chromic gut sutures, passing through the serosa of the stomach, plicating the gastrocolonic omentum and terminating in a longitudinal band of the transverse colon. The stomach was then affixed to the anterior abdominal wall above the umbilicus after the method of Rovsing. Then the fundus of the uterus was sutured to the abdominal anterior wall above the pubis.

Postoperative History.—As soon as convalescence was established her bowels moved every day without cathartics. At the end of five months, the patient was reported by her physician to have increased in weight thirty-five pounds; to be of good color and absolutely without gastric disturbance of any kind, bowels moving regularly every day without cathartics; menstrual periods regular and painless. Patient has been converted from a chronic invalid into a woman of good health and usefulness.

Technic of Ileocolic Resection.—Abdominal incision six inches in length through the outer portion of the right rectus muscle; small intestine pushed over to the left and protected by moist gauze pack; terminal ileum, the cecum, ascending colon and first portion of the transverse colon pushed to the left and by retraction of right edge of incision the right parietocolonic cul-de-sac exposed; pelvis and hepatic region packed off so as to isolate the ileocecal coil.

First step: Incise peritoneum along outer side of ascending colon, beginning at the peritoneal reflection of the cecum and the terminal ileum, and passing upward to the hepatic flexure. Inner edge of the incised peritoneum is stripped toward the middle line with a gauze-covered finger, carrying with it the ascending colon throughout its whole length together with the cecum. This procedure is continued until entire portion of intestine to be removed is so loosened up that it can be easily brought up through the wound. Into the space behind the freed and drawn out intestine further packing is

introduced. Into the upper part of this space behind the intestine the finger of the operator is passed, and guided by it an incision is made into the mesocolon on the front; which cut is enlarged until the superior mesenteric artery, and its ileocolic branch are brought into view. The ileocolic artery is now doubly ligated and divided. Should the right colic branch arise separately it will require separate ligature. The peritoneal reflection is then divided upward and downward from this incision from the transverse colon to the ileum. All vessels are ligated as met with.

The parts to be removed, thus freed, are now held attached only by the bowel above and below. A Payr's clamp is now applied to the ileum at a distance about six inches from its junction with the colon. About one inch distal to it a second clamp is applied. The bowel is then divided between the clamps, as close to the proximal clamp as possible, preferably by a cautery. If knife or scissors should be employed, the resulting cut ends should be sterilized at once with a cautery. The distal free end with clamp controlling it is wrapped in a compress and laid aside out of the way. The end of the ileum is then closed by a running suture of silk or linen thread. The suture should begin at the mesenteric border, from which it proceeds from the left to the right by a succession of stitches that include the clamp until the opposite border of the bowel is reached. The clamp is now withdrawn, and the stitch drawn tight. By this method the cut ends are infolded, and a secure closure of the bowel is effected. The needle is then made to return along the line of suture by successive stitches, until the starting-point is reached at the mesenteric edge, where it is knotted and drawn tight. The final closure of the puckered end should now be done by still further invaginating it, and applying a third series of interrupted sutures. The transverse colon is divided in a similar manner. The rejected portion of the bowel is now removed from the field, and such change of protective packing made as occasion may require, and anastomosis between the ileum and transverse colon effected. In doing this portion of the work it is important that no cul-de-sac should be left in either segment of the bowel beyond the anastomosis. To insure this the closed end of the ileum and colon should be brought side to side and the two closed extremities should be made to abut against each other, and secured by suitable sutures to each other *vis à vis*. The lateral anastomosis between the ileum and the colon is then made in the usual manner, so as to secure an abundantly free opening between the two portions of intestine, not less than two and one-half inches in length. The toilet of the region is then made, and the free edge of the original peritoneum incision is sutured to the corresponding edge of the mesentery, and the transverse mesocolon. The abdominal wound is then closed.

Technic of Total Colectomy.—Median incision, six to eight inches long, from two inches above the symphysis upward; expose cecum and proceed with the detachment of the ileocecal coil as already described in the preceding section. Identify and ligate the vessels supplying

the transverse and descending colon and sigmoid coil in the same manner and divide the peritoneal leaflets of the mesocolon. Then divide the sigmoid at or just above its junction with the rectum; remove the cut-out bowel and close the distal bowel orifice by the suture described. The termination of the ileum and the rectum adjacent to it are brought into convenient apposition, and a lateral anastomosis made. Finally the free incised margin of the mesentery of the ileum is sutured to the peritoneum forming the outer wall of the mesorectum. This suture, when drawn tight, brings the rectum to the middle line of the pelvis, and fixes it securely in that situation, immediately beneath the position occupied normally by the divided end of the ileum, and closes the interval between these two mesenteries, through which a loop of bowel might otherwise pass and give trouble.

DIVERTICULITIS.

While diverticula have been found in all portions of the intestinal canal, from duodenum to rectum, they are most frequent in the descending colon and sigmoid. It is, however, only within the last few years that their surgical significance has been fully recognized. Graser,[1] in 1899, first demonstrated the association between diverticula and circumscribed inflammatory reaction occurring about them. Since that time a rapidly increasing number of observations, especially those from the Mayo Clinic, has placed the recognition of this condition on a fairly firm basis.

Etiology.—Diverticula of the intestine may be either congenital or acquired. The majority thus far recognized which have received adequate pathological examination have been of the acquired group.

They may occur as single or multiple pouches. In their earlier history they are small protrusions which possess all the intestinal coats, but as they increase in size the muscular coat becomes thinned and disappears, the mucosa atrophies and submucous fibrous coat alone remains (Fig. 36). Males are apparently affected with the condition something over twice as frequently as females, and obesity would seem to be an influencing factor, or at least the propensity to take on flesh rapidly.

Pathology.—Pathologically the great majority of diverticula met with represent merely herniæ of the mucosa through the muscularis, and as McGrath has pointed out these occur most commonly where the latter is penetrated by the bloodvessels. They vary in size from a pea to a golf ball (Figs. 36, 37 and 38), usually having a rather patent opening, seldom pedunculated and are frequently filled with fecal concretions. As long as they empty themselves promptly and fully they provoke no symptoms, but when fecal concretions form and are retained within them, irritation and infection follow, ulceration takes place and peridiverticulitis with local exudation, tumor

[1] Arch. klin. Chir., 1899, vol. lix.

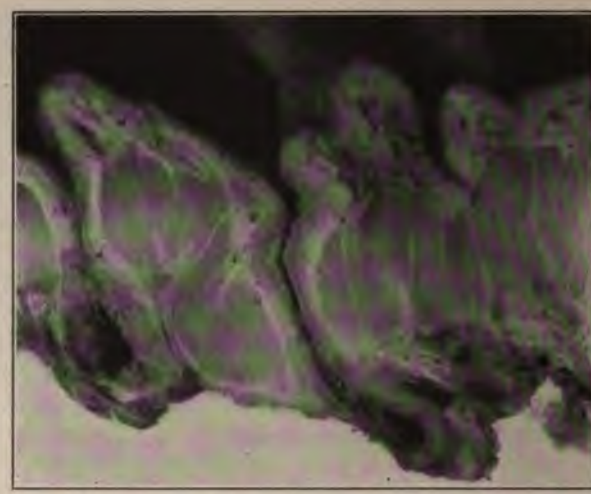


FIG. 36.—Diverticulum of sigmoid protruding through the muscularis; in terr pouch a fecolith, zone of peridiverticulitis created. (After Mayo.)

FIG. 37.—Diverticula of colon at junction of descending colon and sigmoid fle with stenosing peridiverticulitis.

(*Fig.* 36), abscess and sometimes general peritonitis develop; the abscesses may perforate into the bladder, or open on the external abdominal wall, with the formation of fecal fistulæ. An ulcerating diverticulum may degenerate into a carcinoma.

FIG. 38.—Multiple small diverticula of descending colon demonstrated by the retained bismuth hours after the general discharge from the bowel of a bismuth enema.

Symptoms and Diagnosis.—In those cases in which there has already occurred tumor formation (peridiverticulitis) the chief problem is to differentiate the condition from carcinoma. As ruling out carcinoma and suggestive diverticulitis, the following data have been formulated by Giffin who states: (1) That the suggestions of malignancy are seldom noted in the general picture; (2) a tendency to obesity and continuance of good nutrition is frequently observable; (3) a long history of attacks of low abdominal pain, localizing in left lower quadrant; (4) a history possibly of the formation and subsequent disappearance of a mass; (5) failure to get a history of gross blood repeatedly passed in stools; (6) occasional finding of inflammatory vesical fistulæ.

In those cases where no extramucosal inflammation has occurred the pictures presented are very confusing and may vary from being quite

symptomless to those evidencing the most severe colitis. Fig. 37 shows the presence of multiple fairly large diverticula in the descending colon, and a defect caused by a peridiverticulitis at the areas indicated by the arrows, yet the only complaint was gas and constipation. Fig. 38 shows a dozen perfectly demarked diverticula which caused disturbing irregularity of the bowels, accompanied by difficulty in retention at times. Again, Fig. 39 shows the radiograph of a very stout man suffering from acute intestinal obstruction from an acute inflammation of a diverticulum situated at the hepatic flexure. Many inactive diverticula are to be seen in the descending colon and sigmoid. He had never had any untoward symptoms before.

The diagnosis would be made much more frequently than it is if proper technic were employed in searching for them, and if the possibility of the condition were always before the examiner. There is little doubt that many of the cases of the varying grades of colitis, so frequently met with, are due to these diverticula. The detection of diverticula has an important influence upon the prognosis. Thus, of tumors of the sigmoid, approximately 10 per cent. are at first innocent masses of inflammatory reaction surrounding a diverticulum. While in about 25 per cent. of the tumors thus formed there is later engrafted on them carcinoma. Clinically considered carcinoma may be best differentiated by the early discovery of macroscopic blood in the stools. There is usually no particular tenderness or evidence of inflammatory reaction in the early history of carcinoma. An early sense of discomfort is usual, and there is a rapid loss of weight and strength, and finally the radiographic examination shows an irregular defect, but no diverticula present in that point or in the adjacent and contiguous bowel.

Radiographic Examination.—Plates are exposed eight, sixteen, twenty-four, thirty-six and seventy-two hours after a bismuth or barium meal has been given in cases where this condition is suspected As noted in Figs. 37, 38 and 39 the varying sized diverticula are clearly outlined by the residual opaque substance remaining in them, while the main column has passed on. In addition a bismuth or barium enema, and it is advisable to employ the substance which has not been used for the meal, as the contrasting shadow is more evident, is introduced, and frequently small diverticula which may not have been previously filled become visualized as bulbous excrescences on the otherwise smooth column. The opaque material will frequently remain in these crypts for many days. The single examination of the colon, so frequently employed, may be quite valueless from a diagnostic standpoint, when, if they had continued it over a period of two days, it would have given much valuable information.

Treatment.—*Non-operative.*—The employment of bismuth in large doses by enema has proved of marked benefit in those instances where the diverticulitis has not become extramucosal, and where colitis has resulted from the irritation. Lavage of the colon, with starch or gelatin solutions, has been of use in some instances. Rest, dietetic

regimen and the prevention of constipation and fermentation are contributory factors in recovery and prophylaxis.

Operative Interference is indicated in all cases of abscess of tumor formation. If the inflammatory area is of such little extent as to admit of excision, that course should be followed and the intestinal opening closed. Drainage should be provided for in closing the wound. If, as is generally the fact in cases which come to operation, there is present much inflammatory infiltration of the intestinal wall and of the mesentery, with more or less mesenteric thrombosis, generous resection of the affected segment of intestine and mesentery should be done, with abundant provision for drainage of the attendant abscess.

FIG. 39.—Skiagraph taken fifty-four hours after a bismuth enema. Note retained buttons of bismuth at hepatic flexure and in the left iliac region showing a diverticulum at the hepatic flexure (clinically associated with peridiverticulitis and acute intestinal obstruction), and multiple small diverticula in the sigmoid coil.

The method of excision in two or three stages already advised in dealing with megacolon and volvulus (q. v., p. 153) should be followed in the removal of a segment of intestine the seat of a tumor due to a diverticulitis.

ILLUSTRATIVE CASE.—*Multiple diverticula of sigmoid; perforation with formation of inflammatory tumor and intestinal obstruction; resec-*

tion of segment of sigmoid; permanent recovery (Pilcher Hospital, Case No. 482). Man, aged sixty-one years, had always been in good health and led an active life until July, 1912, when he began to suffer from frequent prolonged attacks of colicky pain in the lower abdomen, associated with constipation. When a movement of the bowels was obtained his pain would be relieved. His appetite was good and he had no vomiting, but as a result of his condition he had lost in weight and began to display considerable general depression. The difficulty in obtaining movements of the bowels was constantly increasing.

Examination revealed a deep induration in the left iliac region overlying the brim of the pelvis. Here there was tenderness on deep pressure, and the overlying muscles were somewhat rigid.

Operation, March 26, 1913. Upon opening the peritoneal cavity a large mass was exposed involving the sigmoid flexure, the superior wall of the bladder and the anterior abdominal wall, with adhesions to the neighboring coils of the intestine. That portion of the anterior abdominal wall, which was involved, was cut out *en masse*. That portion which was attached to the bladder was carefully dissected away without opening into the interior of that viscus. The adhesions to the surrounding intestines were separated without accident, until finally it was possible to mobilize the sigmoid and descending colon sufficiently to raise the sigmoid out of the abdomen. Enlarged glands were present in the mesosigmoid. The sigmoid was then detached from its meso and a large wedge-shape section of the meso, containing the enlarged glands, was removed. After the two leaves of the cut meso had been sutured, the freed portions of the sigmoid were brought together and sutured side by side for three inches from the meso outward; the remaining loop, brought outside of the abdomen, was then secured in the wound which was closed about it. Forty-eight hours later the patient having rallied well from this primary procedure, the entire mass lying outside of the abdomen was removed by cautery and scissors, thus establishing a fecal fistula, and leaving secured in the wound the two open portions of the sigmoid parallel to each other and adherent along at least three inches of their course.

A rapid improvement in the general condition of the patient followed, and one month later the spur between the two portions of the bowel was divided, and the two presenting ends of the intestine were brought together and sutured. The fecal current was at once reëstablished. At the end of some weeks, however, a fecal fistula developed, through which for a time there was some leakage, but this gradually and spontaneously closed. The patient rapidly regained his usual weight, and was in perfect health at the last examination January, 1920.

The tumor mass upon examination was found to be purely inflammatory in its nature and to have originated in three diverticula of the sigmoid, two of which had become perforated and had caused a peridiverticulitis, and the inflammatory induration resulting had formed the tumor mass.

ULCERATIVE COLITIS.

Obstinate and intractable diarrhea, due to a chronic ulcerative condition of the mucosa of the colon, may result from infection with amebæ coli, or with bacilli Shiga, or to a mixed infection. Tuberculous and syphilitic infections may cause similar intractable diarrheas, but they are usually easily differentiated. The chronic colitis for which surgical aid is invoked is the later stage of an acute condition usually ushered in sharply by pain and diarrhea. As the frequency of the stools increase they become admixed with

FIG. 40.—Ulcerative colitis involvement of entire colon. Note absence of halistrations.

bright blood, which may be profuse or only present at times, with usually no great amount of tenesmus. The peristalsis of the entire gastro-intestinal tract is greatly increased, and no time is given for digestion. The ingesta appear in the stools practically unchanged, and in consequence of the large amount of fluid lost, the patient rapidly becomes weak and emaciated, and a condition of exhaustion is induced which frequently results in death. There is usually a

diffuse tenderness over the lower abdomen, often most marked in the left iliac fossa, and there develops in many cases a peculiar apathy progressing to a profound melancholia. Perforations in the intestines, hemorrhage and pericolonic abscess are frequent complications.

The process usually begins in the rectum or lower sigmoid and progresses upward. Its extent can be definitely and graphically shown by a radiographic examination as pointed out by Logan and Carman. The involved intestine showing as a rigid tube, devoid of incisuræ, is usually of diminished lumen.

Treatment.—*Appendicostomy* and *cecostomy* may be resorted to for the purpose of making an avenue for the direct introduction of medicated solutions for the irrigation of the colon. For which irrigation solutions of quinin 1 to 300 to 1000, silver nitrate 0.5 to 1 per cent. krameria 10 per cent., formalin 1 to 500 either alone or in combination with carbolic acid 1 to 500 are recommended. Such irrigations are usually followed by temporary benefit, but in many cases the patient relapses after a suspension of the irrigations. Hypodermatic injections of emetin should be used in all instances where amebic infection has been identified or suspected. It possesses a specific property in the destruction of amebæ. The form of this substance used is either the hydrochloride or the hydrobromide, the former apparently being more satisfactory. It is injected subcutaneously twice daily, or even more frequently, if the case is very severe, beginning with $\frac{1}{8}$ grain and increasing to $\frac{1}{3}$ to $\frac{1}{2}$ grain, every few hours until $1\frac{1}{2}$ grains have been taken. This is practically equivalent to between 90 to 130 grains of ipecac. It does not cause vomiting, and is practically to be classed as a specific, checking all the symptoms with remarkable promptness, and permitting of a very rapid gain in weight. It has no action on colitis caused by Shiga's bacilli. The above dosage is, as a rule, sufficient, even in most obstinate cases, but it is probably best to continue with a small dosage for a week or so after the symptoms have been relieved.

Technic of Appendicostomy.—1. The abdominal wall should be opened by a two-inch oblique incision in the right inguinal region over the appendix by a gridiron intermuscular splitting procedure.

2. Through this opening deliver the appendix and examine carefully to ascertain that it is of length and caliber to admit of being brought out upon the surface without undue tension, that it is not twisted and that its lumen would admit a small calibered catheter.

3. Prevent retraction of the appendix by a catgut stitch fastening the meso-appendix to the muscle in the middle of the wound; a similar stitch through the wall of the appendix itself to the other side of the wound completes its fixation. The wound is then closed by sutures, with care to avoid occlusion by pressure on the appendix itself. Dressings are applied with a cover of rubber tissue over the protruding appendix.

4. After an interval of forty-eight hours or more, for adhesions to form, the protruding portion of the appendix is cut off about a half inch above the surface of the skin, and into the lumen of the appendix

thus exposed introduce a smooth catheter into the cecum (Fig. 41). It should be possible easily to pass a catheter of from No. 12 to No. 15 French gauge. The catheter may be introduced as often as may be required.

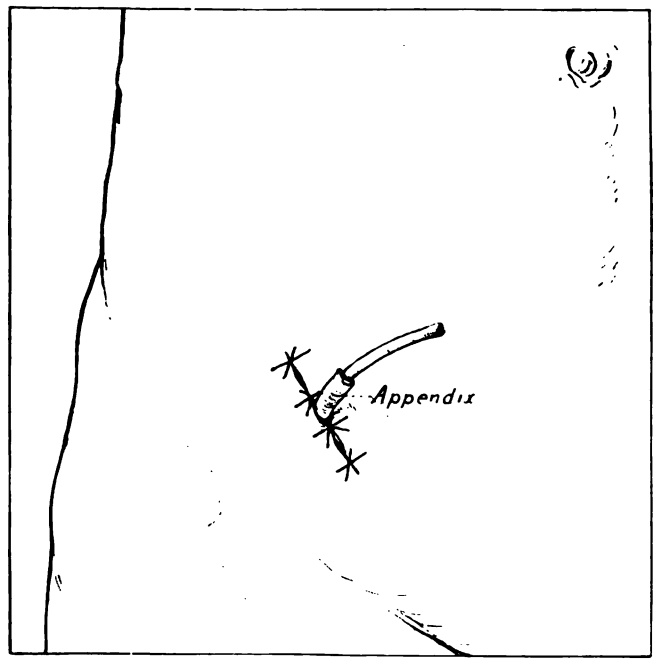


FIG. 41.—Appendicostomy. The appendix has been brought out and secured in the operative wound. The distal portion of the appendix has been cut away and a catheter inserted into the open lumen of the appendix.

5. Closure of the fistula, when it is no longer desired to keep it open, may usually be secured by destroying its mucous lining by the cautery tip. In the event of this simple means failing, the wound may be reopened and complete removal of the appendix done in the usual way.

Valvular Cecostomy is in many instances preferable to appendicostomy, owing primarily to the fact that the appendix is so frequently found diseased; and secondly, that it becomes obliterated easily if the catheter be withdrawn.

Primary Ileostomy with Subsequent Closure.—Sistrunk has had most favorable results in putting the entire colon at absolute rest by doing an ileostomy and allowing it to remain open for twelve to eighteen months, when a direct closure can be done, if there have developed no obstructive cicatrices during the healing process, as shown by radiographic examination; or partial or total colectomy if this seems necessary.

PERICOLONIC BANDS AND MEMBRANES.

Repeated references have been made in preceding sections to parietocolonic adhesions, membranous envelopes or films, and fibrous bands which are frequently met with, especially along the right bowel between the terminal segment of the ileum and the first part of the transverse colon. The consistency of these new formations varies from that of a fine veil-like wide spreading envelope, diaphanous but

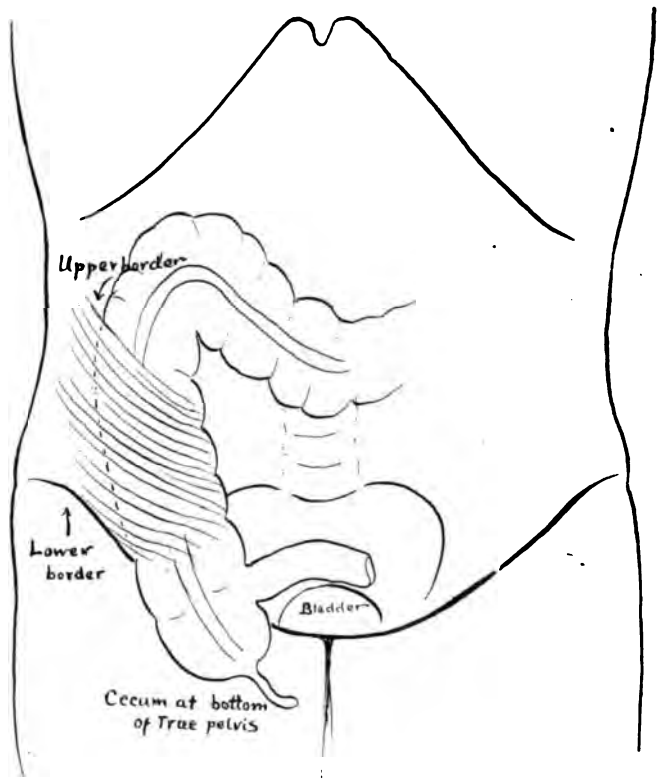


FIG. 42.—Typical pericolic film with upper border at hepatic flexure and lower just above cecum. Chronic appendicitis. Ptosis of cecum and ascending colon into true pelvis. Cecum and appendix lying at bottom of true pelvis. (Eisendrath.)

vascular, forming a distinct layer easily separable from the true peritoneum beneath it, to more thick band-like ribbons of connective tissue which spring from the adjacent parietal peritoneum, from which they pass over upon the anterior surface of the intestine, loosely connected with the underlying intestinal peritoneum, finally blending with the inner surface of the gut or its mesocolon (Fig. 42). The thicker bands are usually portions of more widely extending thinner films, of which films portions seem to have undergone the thickening that has finally converted them into bands or comparatively dense

membranes. When the location of these bands is such that they encircle the intestine they may so constrict it as to markedly diminish its lumen (Fig. 43); if attached to a flexure, as the hepatic, they may make its angle so acute as to become a serious obstruction, or by traction may produce an obstructive angle where none should exist, as in the ileal kink of Lane. When the membrane spreads out over the whole of the anterior face of the colon and cecum it may cripple the peristalsis by its multiple plicating influence upon the whole intestine involved (Jackson's membrane) (Fig. 44), or by binding together the ascending and first portion of the transverse colon, like the two barrels of a shotgun, causing the normal angle at the hepatic flexure to be so acute as to be obstructive (see Figs. 26 and 27).

FIG. 43.—Photograph (not retouched) of ileocolic region of female adult cadaver—died of cancer of stomach, without metastases. *1*, reflection on parietal peritoneum of fold of Jonnesco (Jackson veil or pericolic membrane); *2*, upper limit of fold or membrane; *3*, lower limit of fold or membrane (1½ inches above end of cecum); *4*, inner limit of fold or membrane (fuses with mesentery on inner side of ascending colon). (Eisendrath.)

As to the origin of these films and bands, the studies of Flint, Eastman, Eisendrath and others have demonstrated that during fetal life there may often be found in the abdominal cavity a film-like peritoneal fold reflected upon the surface of the ascending and of the descending colon respectively, from the adjacent lateral parietal wall. This presumably is a vestige of the mechanism by which normal fixation of these portions of the intestine has been secured. Normally it has disappeared by atrophy and absorption by the time the full maturity of the embryo has been reached. In occasional instances it persists more or less perfectly, and furnishes a basis for the development in later life of some at least of the pericolic films which embarrass

and obstruct colonic peristalsis and engage the attention of the surgeon. During childhood and youth little if any disadvantage arises from the persistence of these fetal remains, they are simply accessory anchors to the intestine which they embrace. But when with the advance of life there have been formed faulty habits as to defecation, or improper modes of clothing have been adopted, or the relaxations attending child-bearing or obesity have developed, or accidental traumatism, or infective accidents (appendicitis), have occurred which interfere with normal peristalsis, or produce conditions of prolapse and overloading with retention of putrefactive masses in the first portion of the colon, the symptoms of intestinal stasis are developed.

FIG. 44.—Parietocolic membrane causing double-barrelled shotgun deformity of ascending colon. (Eisendrath.)

The intermittent tugging of the weighted prolapsed bowel on its fibrous supports and envelopes tends to induce an hypertrophy in them. The putrefactive processes going on within the intestine add the effects of a low grade persistent infection which aggravates the previous hypertrophy by its own proliferative stimulus. An ever-increasing obstruction and stasis result from the vicious circle thus established. It is not necessary, however, to ascribe all pericolonic films and adhesions to the persistence of embryonic conditions. Mechanical irritations and long-continued and oft-repeated mild infections of the peritoneum covering the cecum, appendix and colon are capable

of provoking a proliferative inflammation, of a low type, that may create over a greater or less area of such peritoneum a fibrous film, or result in adhesions to adjacent surfaces that ultimately form bands and membraniform sheets. We have seen all grades of the development of these pericolonic films in various cases in which the bowel has been exposed in the course of operations for the relief of chronic obstructive and diffuse inflammatory conditions, in which the causative agency of the local infection was clearly discernible in the production of such a film as an organized exudate, and in which there was no ground for the theory of the existence of a previous embryonal vestige. The most reasonable conclusion seems to be that, while in a large number of cases pericolonic obstructive bands and membranes have as their basis such vestiges, they have nevertheless been converted into important pathological conditions by the addition of proliferative elements of inflammatory origin; in the remaining cases—by no means a negligible quantity—they are the products of local inflammatory processes which have their origin in conditions within the intestine that have developed infections that have been transmitted through its walls.

Although, these bands are met with most frequently on the right side, they are occasionally found along the descending colon and especially at the root of the mesosigmoid.

Diagnosis.—The symptoms which these pericolonic bands and membranes produce depend entirely upon the degree of interference which they occasion with the proper function and circulation in the part. Discomfort, increasing at times to positive pain, in the right iliac region, if the condition is a right-sided one, is quite constantly present. Deep pressure in this region will elicit tenderness. Exacerbation of this tenderness, owing to errors in diet or exercise, occur from time to time, accompanied by colicky cramps, significant of paroxysms of muscular spasm in the bowel musculature.

Fecal Stasis.—In most cases it is only when the progress of the intestinal contents is interfered with by these films and bands sufficiently to produce a notable degree of *fecal stasis*, that the advice of the surgeon is sought. The symptoms indicative of fecal stasis, for more full description see section on Colonoptosis, are practically always associated with those caused by pericolitis. Indeed the systemic symptoms produced by the auto-intoxication resulting from the fecal stasis may so dominate the situation that the less strongly accentuated local symptoms may be quite overlooked, or regarded as of little importance. Pain is often referred to the stomach, and the secondary gastric distress and digestive disturbance may be the most noticeable condition present. A chronic appendicitis is so frequently an accompaniment, either as effect or cause, of pericolitis and fecal stasis, that its symptoms will be mingled with or should be considered as a part of those significant of pericolitis.

In any case of chronic pain in the right iliac region, associated with intestinal disturbances, skiagraphy of the cecum and colon, filled with

bismuth emulsion, are of great assistance in helping to arrive at a positive diagnosis. By the aid of the bismuth filling the location and degree of a constriction, the presence of an angulation and the amount of ptosis, if any, can be plainly declared.

Exploratory Incision as a Means of Diagnosis.—While a due consideration of the local and general symptoms which attends cases of membranous pericolitis is sufficient to establish a strong probability of the existence of that condition in a given case, and the findings of the bismuth *x*-ray picture may corroborate the opinion formed, nevertheless, an exploratory incision is requisite to fully establish the diagnosis, estimate the full extent and nature of the condition, determine its amenability to treatment, and point out the exact procedures needed to best overcome the conditions found.

In a large proportion of cases the appendix is involved in the infection process, if indeed it has not been its original nidus, and it is probable that a case will come to operation with the primary diagnosis of appendicitis. It occasionally happens that when the appendix is exposed the changes found in it do not seem commensurate with the symptoms previously existing. In every such case the incision should be made sufficiently free to permit of full exposure and careful examination of the terminal portion of the ileum and the cecum and colon as far as the hepatic flexure. More than this, it is desirable in many cases that the gall-bladder and pylorus be also palpated and their condition ascertained. In many cases the appendix will already have been removed months or years before, and the persistent continuance of the right iliac symptoms notwithstanding the removal of the appendix is the occasion of the call for relief.

The best place for such an exploratory incision is along the outer border of the right rectus muscle, or through its substance, opening its posterior sheath. A primary longitudinal incision in this location with its upper end at a point somewhat above the umbilicus and extending downward some three inches or more will give good access to the region involved. Such an incision can readily be prolonged in either direction as the subsequent needs of the exploration may indicate.

Treatment.—The primary indication of treatment after the abdomen has been opened is to cut all the confining bands and remedy any sharp angulation that may be demonstrable. A thin pannus-like membranous veil spreading out over the anterior wall of the intestine as a whole need not be removed *in toto*, but any cord or band-like aggregation of its fibers should be cut, possibly repeatedly, until full relaxation is obtained.

All raw surfaces produced by the freeing incisions must be covered in by peritoneum secured by sutures, so as to prevent the renewed formation of crippling adhesions.

NEOPLASMS OF THE COLON.

These consist chiefly of actinomycosis and tuberculosis of the cecum; polyposis, adenoma, lipoma, diverticula and carcinomata of any part of the large intestine.

Actinomycosis.—Actinomycosis is almost without exception situated in the cecum and appendix although it has occurred in the course of the colon. Its diagnosis rests upon the slowness of the course,

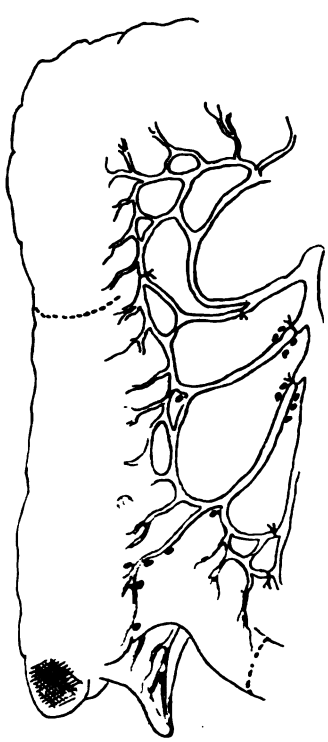


FIG. 45. — Carcinoma of cecum, showing lymphatics usually found to be involved, extent of resection necessary for their removal indicated by dotted lines and points at which ligatures must be applied.

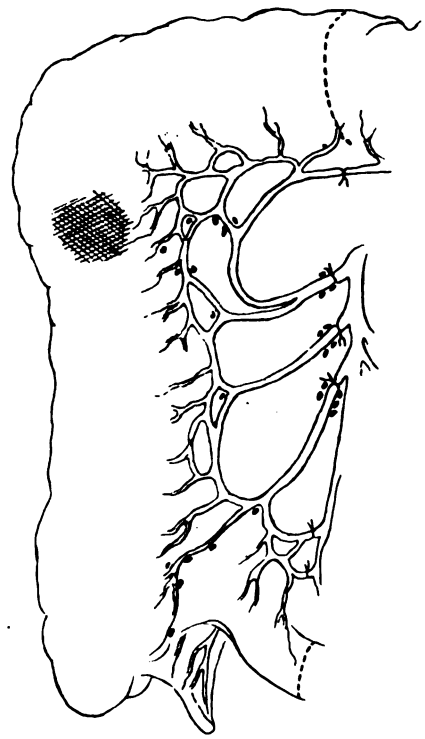


FIG. 46.—Carcinoma of hepatic flexure, showing lymphatics usually found to be involved, extent of resection necessary for their removal indicated by dotted lines and points at which ligatures must be applied.

denseness of the tumefaction, marked secondary infiltration of abdominal wall and eventually the discharge of pus containing the actinomyces from the abscesses. The best treatment is that of drainage after curettage and repeated irrigations with peroxide and simultaneous administration of potassium iodide according to Waring.

Tuberculosis.—Tuberculosis of the cecum and colon occurs in two types, the ulcerative and the hyperplastic. It occurs usually in people from twenty to forty years of age and it frequently seems to be

the only tuberculous lesion present, being probably the result of infection through the ingesta. The symptoms complained of are usually those of chronic appendicitis accompanied often by diarrhea, the stools showing blood reactions. If allowed to continue numerous fistulæ form and either discharge externally or into the intestine. The hypertrophic form, which is of more frequent occurrence, usually begins with systemic symptoms as anorexia, various phenomena of indigestion, frequently giving symptoms which are difficult to differentiate clinically from duodenal ulcer and only showing vague localized symptoms in the right iliac fossa. The tumefaction is invariably palpable, is usually hard, frequently nodular and sausage-shaped.

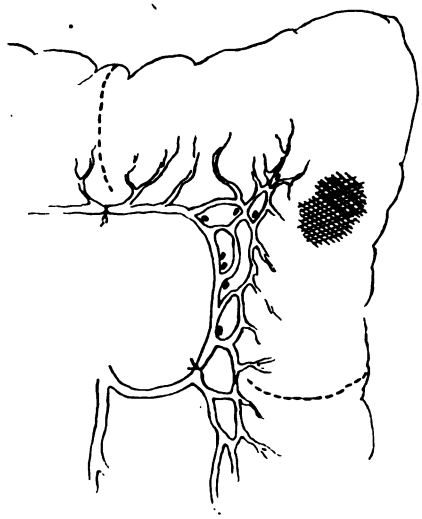


FIG. 47.—Carcinoma of splenic flexure, showing lymphatics usually found to be involved, extent of resection necessary for their removal indicated by dotted lines and points at which ligatures must be applied.

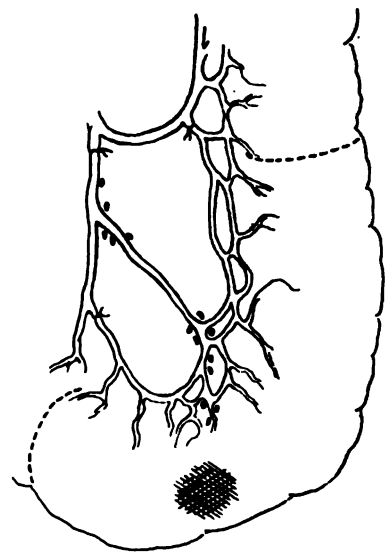
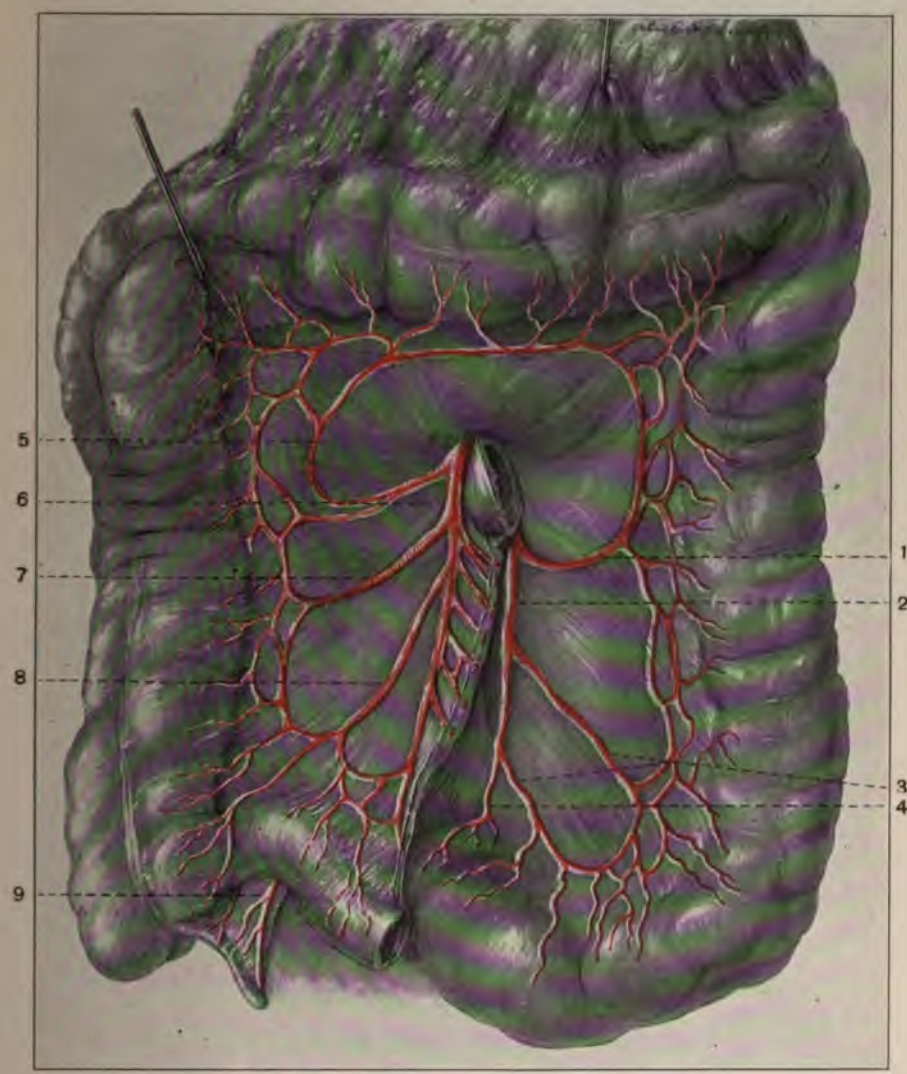


FIG. 48. — Carcinoma of sigmoid, showing lymphatics usually found to be involved, extent of resection necessary for their removal indicated by dotted lines and points at which ligatures must be applied.

It is not particularly tender to pressure. Obstructive symptoms supervene and after a course of from one to three years usually terminate the life of the patient if unrelieved. The differential diagnosis is of importance from the prognostic standpoint. It is usually fairly easy to differentiate from appendicitis on account of the slowness of onset and the presence of a dense mass. Actinomycosis should be thought of but it is quite rare, and if any tissue or fluid can be obtained the actinomyces can be found. The most difficult distinction is from malignant growths. In cancer the entire course is as a rule much more rapid, stenosis intervenes much more rapidly, and the tumor is more irregular. The development of a cancerous

PLATE I



The Arterial Supply of the Large Intestine.

1, Left colic artery; 2, inferior mesenteric artery; 3, sigmoid artery; 4, superior hemorrhoidal artery; 5, middle colic artery; 6, superior mesenteric artery; 7, right colic artery; 8, ileocolic artery; 9, appendicular artery.

cachexia is very suggestive. The treatment in either case is similar, namely complete extirpation with resection of the glands as far back as the origin of the ileocolic artery. (See Plate I and Figs. 45, 46, 47, 48.) The intestine should be resected back eight inches on the ileum and at the junction of the upper and middle third of the ascending colon so as to include the right colic artery and its accompanying glands. Lateral anastomosis between the lower ileum and ascending colon should follow.

Polyposis or Multiple Adenomata.—Polyposis or multiple adenomata are not infrequent in the colon and the development in many instances of malignant degeneration of individual polyps makes their recognition of extreme importance since their surgical eradication is possible. They occur most frequently in the young and are rarely noted after the age of forty. The symptoms are irregular but consist chiefly of interference with normal colonic function, evidenced by attacks of constipation, alternating diarrhea, the occurrence of blood in the stools, tenesmus at times, irregular colicky sensations at others. There may be no interference with the normal health but on the other hand the condition may lead to a most profound melancholia and marasmic state. Frequently their presence may be inferred owing to the fact that they are multiple and occur in the rectum or sigmoid and can be seen on proctoscopic examination and removed. If after such procedure a continuance of the discomfort and blood in the stools persist, the thought should be entertained that the upper colon might also be the seat of similar processes. The treatment is essentially surgical and varies from a local resection to a complete colectomy according to the area involved.

Carcinoma.—The occurrence of carcinoma is relatively frequent in the large intestine, having a relation of one to four to cancer of the stomach, based on an analysis of 1000 operated cases. It may appear in any part of the large intestine but it is met with most frequently in the rectum, and then in order of frequency respectively in the ascending colon, the sigmoid loop, the splenic flexure, the transverse colon and the descending colon. This is shown graphically in Fig. 49. It is of slow growth, forms metastases quite slowly and lends itself during its early stages to such possible complete removal that its early recognition is of the utmost importance.

The clinical symptoms presenting will, of course, depend greatly on the situation of the growth and its histological characteristics, whether it is annular, circumscribed, scirrhus, medullary or infiltrating.

Carcinomatous involvement of the colon is usually observed in persons past middle age, although it has been known to occur in young people. The onset may be insidious or occasionally acute. Usually there is developed a slowly increasing cachexia and loss of weight and strength, with the onset of obstipation, frequently alternating with diarrhea, most usually foul, containing much mucus and blood in greater or smaller quantities. Accompanied by gas formation proximal to the obstruction and the occurrence of cramp, usually

relieved on passing of flatus. Much borborygmus, due to the anti-peristalsis, is evoked.

Fortunately the scirrhus type is the most frequent of occurrence, as it causes stenosis early, before marked metastases have taken place, thus rendering complete removal relatively easy. The soft medullary

FIG. 49.—Fairly normally festooned colon outlined by bismuth enema, patient prone. The numbers indicating graphically the varying sites of carcinomata of the large intestine in the order of frequency of occurrence. (Note radiographic demonstration of marked stricture of appendix.)

or fungoid type more usually cause early appearance of bloody and fetid stools, owing to the erosion and sloughing off of the inner surface. In addition, owing to their great vascularity, they grow rapidly, infiltrate surrounding and adjacent viscera and tend to distant or transplant metastasis.

Diagnosis.—Palpable tumor of the large intestine is demonstrable in the majority of cases but should not be taken as a criterion to counsel against exploration, as frequently much of the mass may be formed by inflammatory tissue or impacted feces. Acute intestinal obstruction occurs when a lumen that has been gradually narrowing becomes suddenly blocked by a foreign body, such as a fruit pit or fecolith, etc., although no antecedent history of bowel derangement may be elicited.

The greatest aid for ascertaining the presence of carcinomatous involvement of the colon and in correctly locating its position is to be found in the radiographic study of the viscus, either by means of the opaque meal, enema or fluoroscopic investigation. Radiographic exposure direct, without the use of any opaque substance, will frequently localize the site of obstruction quite definitely, owing to the fact that the distended intestine is perfectly outlined by gas.

Technic.—Varying preparations have been evolved by Haenisch, Case, Holzknecht, Jangeas, Pfahler, Pers and many others, but probably the simplest which has given the writers equally readable results consists of two glasses of buttermilk in which has been incorporated from four to six ounces of barium sulphate or bismuth subcarbonate which is taken by mouth. An immediate plate is taken to locate the stomach and to afford a study of its contour. Plates are then taken six, eight, twelve, sixteen, twenty-four, thirty-six, fifty-two and seventy-two hours later to record the progress of the meal, or more often, as the nature of the case or the readings of the plates indicate. To this descending column of opaque material an enema of similar composition is added by which the visualization of the large intestine throughout its entire course is accomplished.

The careful observation of the ascent of an enema with the fluoroscope frequently brings out deficiencies of lumen involvement in the colon with the greatest accuracy, and affords one the opportunity of palpating any part of the colon and rotating it at any time. Stereoroentgenography has also a very useful field in depicting this portion of the intestine. Figs. 50–55 give skiagraphic pictures obtained by this process in the presence of carcinoma in various sections of the large intestine.

Where obvious obstruction is met with, and stasis of the column of opaque material noted with erosion of the edges and other defects in the peripheral outline registered, the conclusions are relatively easy to arrive at. The more difficult translations are those inferences made upon cases not presenting stagnation of the content of the colon. Case[1] has summarized these findings well as:

1. Exaggeration of colonic antiperistalsis, giving the appearance of "peristaltic unrest," to the barium content above the site of the lesion with arrest or hindrance in the onward progress of ingested barium.

[1] Interstate Med. Journ., 1913, xx, No. 12.

2. Arrest or noticeable hindrance in the ascent of the barium column when giving enema.

3. Coincidence of a palpable tumor with a point of hinderance to meal or enema.

4. A filling defect in shadow of colon, frequently digitated (indicating cauliflower growth) at times annular defect (scirrhus).

5. Colon frequently distended by gas, gas collections seen surging backward and forward, owing to the alternations of peristalsis and antiperistalsis.

6. Marked ileal stasis when neoplasms involves cecum, ileocecal valve, or first part of ascending colon.

FIG. 50.—Shows filling defect in middle of ascending colon, characteristic of annular involvement. (Radiograph of bismuth meal.) (Dr. J. T. Case.)

Differential Diagnosis.—Differential diagnosis of cancer or other neoplasms of the colon must depend largely on the situation of the growth. Thus, those of the cecum and appendix must be differentiated from ovarian and uterine tumors, retrocecal and appendiceal induration.

Those occurring in the ascending colon and hepatic flexure, and first portion of the transverse colon must be properly differentiated from tumors of the right kidney, cancer of the gall-bladder and neoplasms of the liver, while neoplasms of the transverse colon may be easily confused with pancreatic and gastric tumors as well as occasional mesenteric or omental growths.

In considering neoplasms of the splenic flexure one must be certain that they are not confused with tumors of the spleen or of the left kidney.

The various growths of the ovary or uterus may again become confusing in differentiating a neoplasm of the sigmoid. In any part of the colon one must be able to recognize the fact that the condition present is not due to fecal impaction, or to the presence of a large biliary calculus, which may have ulcerated through, both of which conditions are found occasionally to be present. All of these differential points are considered at length, under their respective sections, to which the reader is referred.

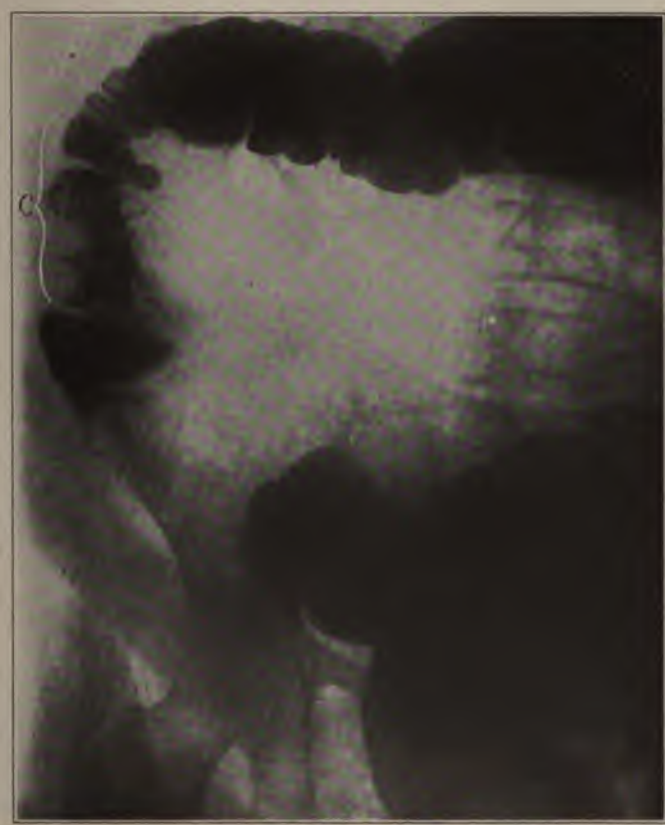


FIG. 51.—Showing extensive carcinomatous involvement of middle third of ascending colon after bismuth enema. (Dr. J. T. Case.)

Complications.—These usually consist of infection due to faulty technic, separation of the line of anastomosis, and in resection of the ascending colon, diarrhea. This is usually, as a rule, transitory and can be checked by opiates. If one is sure of their technic there need be but slight hesitancy after the second day of relieving the gas accumulations by the introduction of a glycerol or molasses enema. Infective processes should be dealt with by suitable drainage being instituted. In instances where complete resection and immediate

restoration of bowel continuity is not advisable, the colon may be liberated and brought up through the abdominal muscles to one side of the main incision so that the growth will lie on the outer surface of the abdomen, being held in place by a glass tube passed under the bowel through the mesentery. A later resection may be done at the convenience of the operator after local adhesions have taken place which will prevent the soiling of the peritoneal cavity. In many instances it will be found possible to keep the intestine in this situation unopened for two or even three days. After removal of the

FIG. 52.—Showing defect in proximal third of transverse colon and hepatic flexure of extensive carcinoma. (Radiograph after bismuth enema.) Case of extension from carcinoma of the stomach. (Dr. J. T. Case.)

tumor, continuity of the intestine can be reëstablished by breaking through the spur by placing a clamp into the afferent and efferent intestine and compressing the intervening tissue, with secondary plastic manipulation of the overlying skin and muscles. The great disadvantage of this type of operation is the fact that all of the glands draining this region are not removed and one cannot be sure that they are not involved. In all carcinomata of the large intestine careful examination of the liver should be made during operation, since extensive metastasis in the liver may have occurred, although the local process may seem rather limited.

Surgical Therapeusis.—The treatment of carcinomata in any position in the colon may be either radical with dissection of the diseased area and a secondary restoration of the continuity of the intestine or radical removal with the formation of a permanent fistula, or a permanent colostomy of necessity where the growth is non-operable. Into a fourth class fall cases in which there are evident metastases

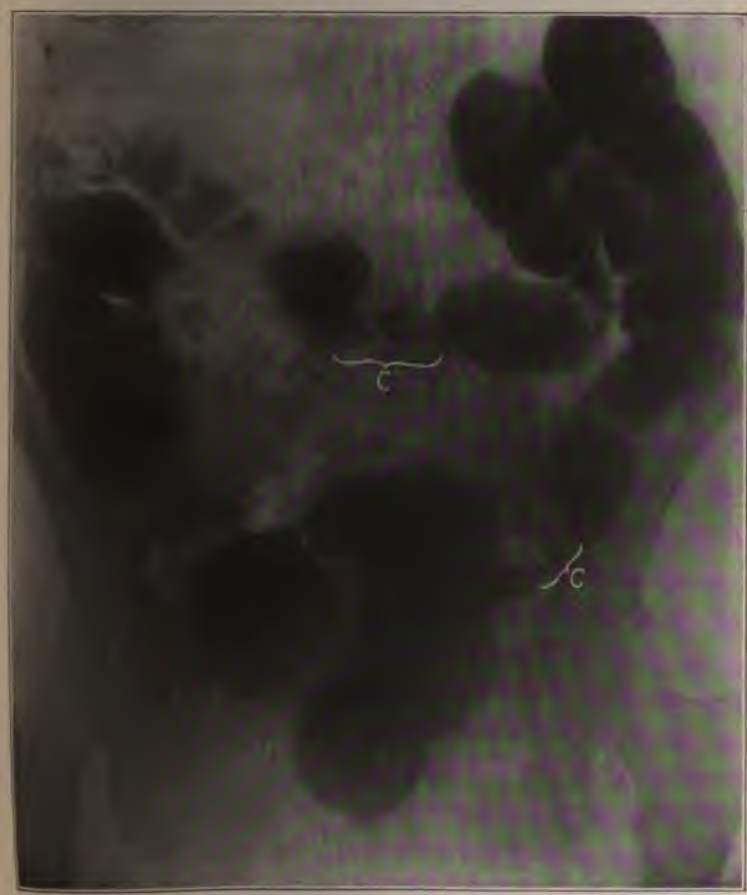


FIG. 53.—Showing a simultaneous double carcinomatous involvement of the colon depicted after bismuth enema; one situated in the middle of the transverse colon; the second situated in the sigmoid; apparently independent processes.

but where the life of the patient is to be spared as long as possible, in which instance the intestine may simply be short-circuited around the tumor.

There are several factors which one should take into consideration prior to excision of the colon: First, it is most inadvisable to have the colonic contents in a fluid state; therefore, any catharsis should be practised at least two days before operation and at least that length

of time be allowed to elapse after the administration of a cathartic before operation to allow the contents of the bowel to become solid or semisolid. It should be remembered that this portion of the intestine contains an extraordinary number of bacteria among which are many virulent strains. Fluidity of the contents apparently ac-

FIG. 54.—Showing defect in middle third of the descending colon after administration of bismuth meal.

centuates their virulence. Again, the question of the degree of obstruction present is a very important feature. Frequently, if the patient is not in too serious a condition, it is wise to temporize in order to relieve the proximal intestine of its contents and gas as much as possible. This can frequently be accomplished by the use of a slow, prolonged Murphy drip and by the use of various enemata,

among the more efficacious of which will be found that consisting of two or three ounces of glycerol in as much warm water. Another which has given good results consists of four ounces each of molasses and hot milk. Enemata, containing turpentine, ox-gall, alum or peppermint, which tend to irritate the kidneys of cases that are already seriously damaged, are to be avoided. A third consideration which

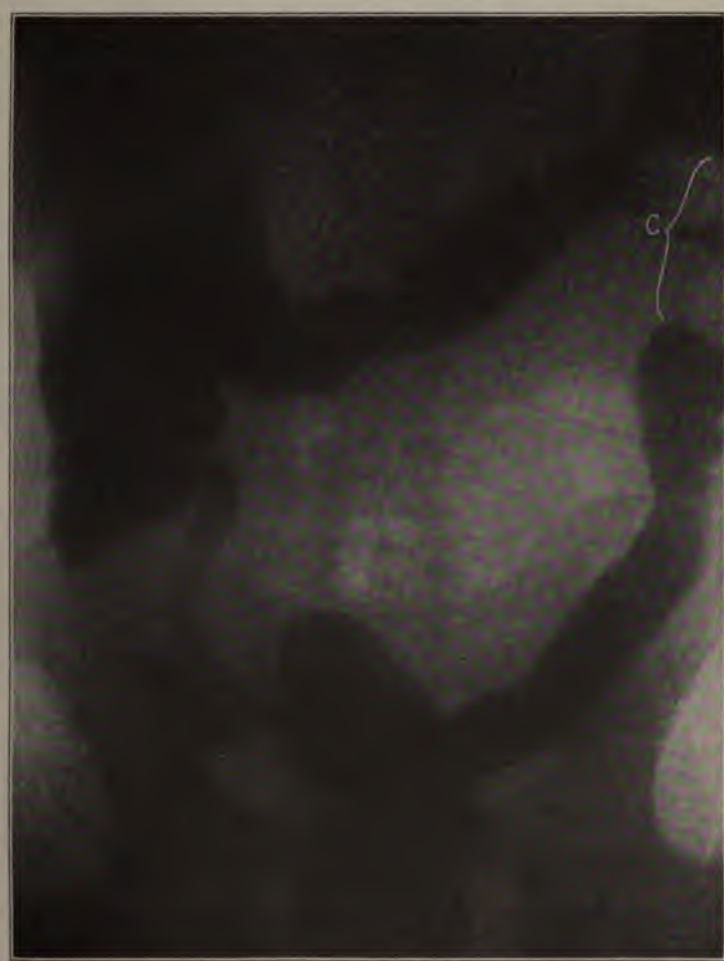


FIG. 55.—Same case as Fig. 54, showing corroborative defect in the same position after the introduction of a bismuth enema.

is most important is the localization of the site of obstruction. This is particularly important in those cases which have developed acutely without any marked previous history. In these instances of acute obstruction one, however, usually finds the tumor to be present in the sigmoid where the lumen of the bowel is smaller and at which position the fecal contents have become solidified. Frequently a mass may be

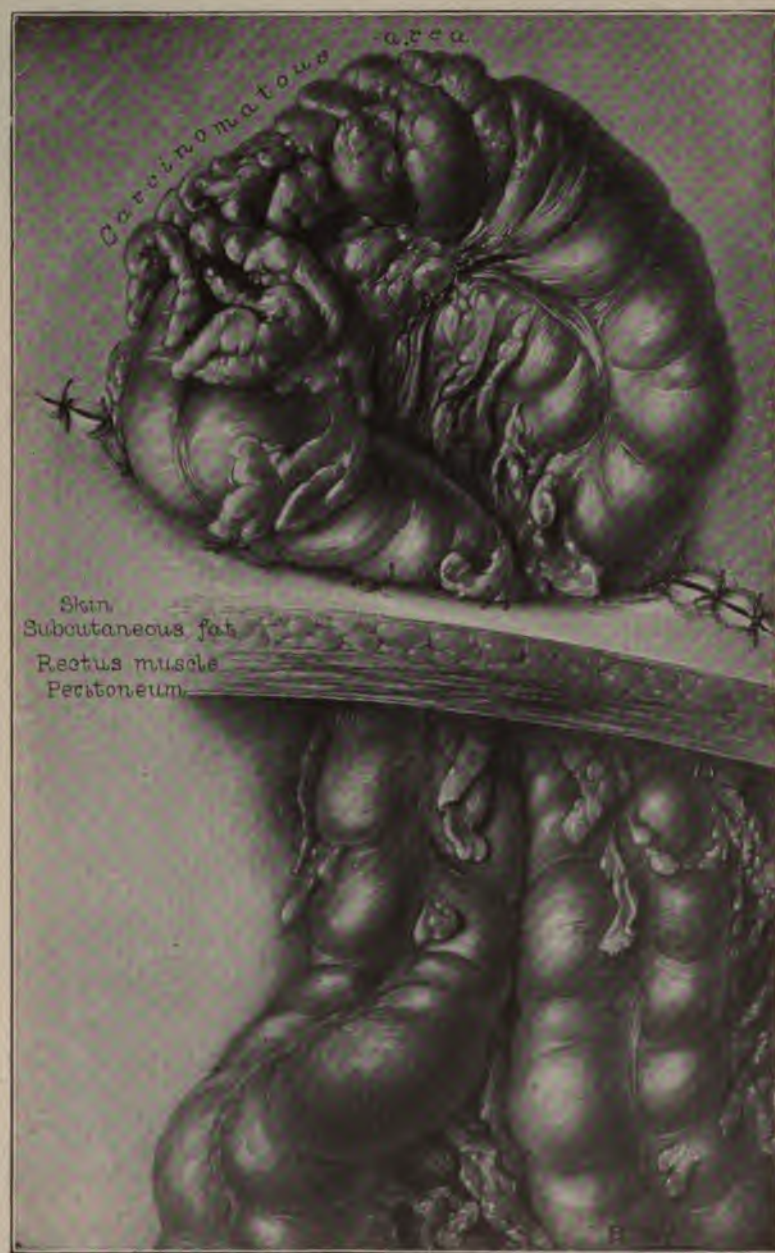


FIG. 56.—First stage of Mikulicz operation completed. The tumor, involved part of bowel, fat and mesentery being drawn outside the abdominal wall, where it will remain until it heals in. It will then be cut away, and the partition between the limbs of the bowel, as sutured together, will be cut out with forceps, restoring the lumen, and the colostomy closed. (Mayo.)

palpated if the patient is placed in a hot-water bath or if relaxation under anesthesia has been obtained. Occasionally one may be able to locate a low lying tumor through the rectum as the result of straining after the administration of an enema. One should always be careful that the stomach is emptied before operation as several instances of drowning under anesthesia have occurred.

Method of Attack.—Where one is not sure of the situation of the lesion an exploratory incision should be made in the median line below the umbilicus, after which, other more convenient incision may be made where indicated. In general, where one is sure of the location of the growth, the incision should be made to the inner side of it. The two-stage method of Mikulicz-Bruns, has reduced the operative mortality in cases of cancer of the colon about two-thirds, and should always be the method of election in instances where there is evident obstruction. Its success depends primarily on the operator's ability to freely liberate the gut so that the loop containing the growth may be drawn well through the abdominal wall without tension (Fig. 56). The serous surfaces of the afferent and efferent portions should be stitched together. The incision should be sutured sufficiently to prevent emergence of the intestine and the skin edges should be attached directly to the intestinal wall. If the degree of obstruction has not been very marked, the extruded loop may be left unopened for several days to allow of primary healing of the abdominal incision, after which time it may be resected, which is best accomplished by dividing the intestine with an actual cautery. If the distention is great and the condition critical, immediate opening will be necessitated, drainage should be provided for at some distance from the wound accomplished probably best by introducing a Pauls' tube. After two weeks the spur may be divided by introducing a clamp on either side of it and destroying it by pressure necrosis. The free edges of the gut may be united then by an extraperitoneal plastic operation.

Should the operator find that it was not feasible to mobilize enough of the colon to draw the entire extent of cancerous involvement out on to the abdominal wall, he should still do a colostomy proximal to the growth and when the patient's resistance had become improved, proceed with the more radical step of colectomy at a later sitting.

The proper mobilization for effective removal may frequently be accomplished without particular technical difficulty owing to the fact that the colon has a long mesentery and because also all of its blood, nerve and lymphatic supply course through its inner leaf. The outer leaf while short and in many instances entirely lacking contains no structures of importance and may be freely divided in any position, after which division the colon may be carried to the middle line or to the opposite side of the abdomen and delivered to the surface so that the intestine may be completely packed off from the abdominal cavity before the resection is begun. It will be found that division of the gastrocolic omentum will similarly liberate the transverse colon. Identification of the larger colonic

bloodvessels which must be ligated will be facilitated by holding the intestine and its mesentery up to the light when they can be very definitely identified. As pointed out by W. J. Mayo there are three things which should be definitely recognized and properly guarded—the duodenum, the ureters and the vasa deferentia. In ligating off the colonic vessels with the various segments of the colon the ligature should be placed at the point of origin of the vessel in question from the main trunk (see Plate I and Figs. 45–48), those from the left side from the inferior mesenteric and those on the right side from the superior mesenteric owing to the fact that the glands follow back directly along the main colonic vessels and frequently one will be found involved in metastatic growth at the junction of the trunk vessel with its branches. This is particularly true relative to a gland along the course of the inferior mesenteric artery where it gives off the sigmoidal artery, necessitating therefore a ligation of the inferior mesenteric artery just distal to the arteria colica sinistra in growths involving the sigmoidal region.

Resection of the Cecum (Fig. 45) necessitates first a liberation of this viscus by a division of the outer leaf of the mesentery which will liberate the entire region involved and the ascending colon for its proximal two-thirds. On lifting this portion of the intestine toward the middle line the ileocolic and the right colic artery are clearly defined springing from the superior mesenteric artery. These are primarily ligated at their origin. Ligature and inversion of the ileum at least eight inches from the ileocecal junction is then done, similarly ligature with division and inversion of the ascending colon at the junction of the middle and superior third. The mesentery is then cut down to the point of ligature of the ileocolic and right colic artery and the resultant wedge removed. Lateral anastomosis is then performed between the terminal ileum and the third portion of the ascending colon.

Resection of the Ascending Colon and Hepatic Flexure (Fig. 46).—Primary mobilization of the ascending colon, hepatic flexure and the first portion of the transverse colon. Ligature of the ileocolic, right colic and median colic arteries. In ligating the latter particular care should be directed to the duodenum which lies directly beneath it. Division and inversion of the ileum eight inches from the ileocecal junction and division of the transverse colon in its middle third followed by lateral anastomosis between the terminal ileum and the third portion of the transverse colon.

Resection of the Transverse Colon.—Ligature of the middle colic artery which will indicate to the operator just how great an area of the transverse colon will be devitalized through the cutting off of the blood supply at which point of delineation the resection of the intestine should be made, and the two ends of the intestine remaining may then be anastomosed laterally.

Resection of the Splenic Flexure (Fig. 47).—This region is easily mobilized by division of the costocolic ligament and the outer peri-

toneal fold. Difficulties in this region frequently arise owing to the fact that while there is not so much involvement by metastases into the lymph glands local adhesive processes form very rapidly in this situation. The resection, as a rule, need not include any more than the middle of the terminal third of the transverse colon and the proximal third of the descending colon leaving the left colic artery intact.

Resection of the Descending Colon and Sigmoid (Fig. 48) is accomplished primarily through liberation of the intestine by division of the outer leaf of the peritoneal fold, early ligation of the bloodvessels at their origin, particular attention being paid to the glands already referred to situated at the origin of the inferior mesenteric artery. If the resultant aperture is not easily bridged between the distal end of the descending colon and the upper end of the rectum or sigmoid, liberation of the splenic flexure should be done so that there will be no tension upon the vessels.

UMBILICAL, VENTRAL AND POSTOPERATIVE HERNIA.

By ANGUS McLEAN, M.D., F.A.C.S.

Our knowledge of the etiology and treatment of umbilical, ventral and postoperative hernia has not increased very materially during the past fifteen years. During the last six or seven years, we have, however, been able to learn much in regard to the permanency of cures effected in cases operated upon as long as fifteen and twenty years ago. Some new methods of operating have been devised, but all, more or less depend upon some form of fascia flapping procedure for their efficacy and in this respect are really modifications of the Mayo operation. Consequently the greater percentage of cures in the hands of operators in general, so noticeable during the latter half of the last decade, has been due, not so much to any new operation, but to a more perfect and thorough manner in which the approved methods have been carried out.

As early as 1836 operative cures for umbilical and ventral herniæ were reported. The methods in vogue at that time certainly were crude but interesting because they point out the various steps and transformations through which the operation for these conditions has passed from that early date up to the present time. For this reason a few will be mentioned.

In 1836 Gerdy[1] performed possibly the first operation for the cure of non-strangulated ventral hernia. He inverted the rupture, skin and all. Then, without making an incision, he sewed the edges of the ring together and finally injected ammonia into the sac, hoping in this manner to bring about its obliteration.

As late as 1882 Bigelow[2] practised this same procedure except that instead of using stitches to bring the edges of the ring together, he held the edges in apposition by means of adhesive plaster.

Simon[3] took the next step and endeavored to hold the edges of the ring in better approximation. He excised a strip of skin from around the hernial opening and secured the inverted skin sac with three layers of sutures: With the first he approximated the edges of the skin sac; with the second the whole thickness of the ring; and with the third the skin itself.

In 1883 another step was accomplished by Burkhardt.[4] This consisted in the removal of the skin overlying the peritoneum.

[1] Zur Radikal operation der Bauchbrueche, Schmidt's Jahrbücher, 1836.
[2] Boston Med. and Surg. Jour., 1882, vol. cvi.
[3] Arch. f. klin. Chir., 1874, xx, 566.
[4] Am. Gynec. and Obst. Jour., 1897, xi.

Up to this time the edges of the ring were simply approximated. This did not prove very satisfactory and recurrences were the rule.

Instead of simply approximating the edges of the hernial ring, Championnière[1] inverted the fascia so that the anterior surfaces came together. These he fixed with a few Lembert sutures. Kocher[2] and Bier[3] later adopted modifications of the method of Championnière.

In 1886, the principle which even today has many defenders was brought out by Maydl.[4] He opened the anterior rectus sheath on both sides of the ring and then sewed peritoneum—muscle, fascia and skin separately.

From that time to the present, the various modifications of the operation for ventral and umbilical herniæ were legion. Various tension sutures were used, some placed circularly, some transversely, some buried and some brought out over the skin. Some operators, notably Biondi,[5] sewed the different layers in different directions, as for instance peritoneum transversely, muscle vertically, fascia transversely and skin vertically.

Wolkowicz,[6] Scatolari,[7] Salistscheff,[8] Dauriac[9] and Bacon,[10] next endeavored to use the recti muscles to cover the hernial opening. The latter, Bacon, made two vertical muscle bands by using a part of the recti muscles near the hernial opening. These he cut transversely at their lower ends, and crossing them, sewed the end of one into the opposite side at the point from which the other had been taken. He thus utilized two strips of muscle which crossed each other in the shape of an X at the center of the hernial opening.

Numerous other workers in this field together with their methods of operating could be enumerated, but space will not permit of such an extensive review. The generally adopted methods of operating at the present day will be discussed below when speaking of the special kind of hernia to which they are applicable. Suffice it to say here, that it is pretty well agreed, that in most cases, we must depend upon fascial planes rather than muscle for the integrity of the abdominal wall. Muscle may assist in the prevention and cure of a hernia, but where there is an absence of fascia or even where there is a weakness of the fascia, the muscle alone will not prevent the occurrence or recurrence of a hernia. Sooner or later the muscle will give way and the formation of a hernia is then imminent.

[1] La hernie embilicale, Paris, 1896.
[2] Chirurgische Operationslehre, Jena, 1907.
[3] Chir. Kongress, 1908.
[4] Ueber eine neue Methode der Radikaloperationen bei Ventraler Herniæ, Wiener med. Presse, October 3, 1884, p. 1298.
[5] Radikaloperation der Nabelbrueche, Centralbl. f. Chir., 1909, p. 62.
[6] Centralbl. f. Chir., 1896, No. 22.
[7] Ergebnisse der Chirurgie und Orthopaedie, Erster Band, p. 461.
[8] Zur Technick der Radikal Operation grosser Bauchbrueche, Centralbl. f. Gynäk., 1890, No. 27, p. 473.
[9] Gaz. d. hôp., 1894, p. 673.
[10] Atlantic Med. Weekly, Providence, 1895, iv, 81–85.

UMBILICAL HERNIA.

An umbilical hernia is a protrusion of some of the abdominal contents through the umbilicus or through an opening in its immediate vicinity. According to the time of life during which an umbilical hernia develops it is classified as: (1) Congenital hernia of the cord; (2) infantile umbilical hernia and (3) adult umbilical hernia.

Congenital Hernia of the Cord.—This is a very rare condition. It is not, strictly speaking, a true hernia but is a defect in development. It is an incomplete approximation of the visceral plates in the region of the umbilicus during intra-uterine life. This form of hernia is very often accompanied by other developmental defects such as hare-lip, cleft palate, etc. Concerning the exact cause of the failure of agglutination of the visceral plates, nothing is known definitely. Anatomically, the coverings of a hernia of this kind are a thin layer of Wharton's jelly and peritoneum. The size of this variety of hernia may vary from that of a pigeon's egg to that of a child's head, in which case there would be an almost complete eventration.

Treatment.—When small, these hernia will require very little treatment. All that is necessary is extreme cleanliness and a well fitting binder, under which is placed a flat pad and the whole snugly stretched across the umbilicus. There should be no projecting knob over the aperture, as this will prevent its closure. A cure usually follows this procedure. For the larger umbilical hernia of the cord, an operation is essential in order to effect a cure. Sometimes it is only necessary to remove the layer formed by Wharton's jelly, freshen the edges of the opening and draw them together. Here the parietal peritoneum is not incised, the whole procedure is done extraperitoneally. However, in the very large herniæ of this class it is necessary to remove both coverings of the hernia, the one formed of peritoneum as well as the layer of Wharton's jelly. The peritoneum is then stitched separately and, next, the freshened edges of the hernial ring are approximated.

Infantile Umbilical Hernia.—This is of far more frequent occurrence than the former. The proportion of male and female infants and children afflicted with this malady is about the same. This is true up to the twentieth year of life. The usual time for occurrence is during the first year. Macready's[1] observations of 209 cases of umbilical hernia in males and 566 cases in females showed that one-half of all the males and about one-fifth of all females developed the hernia during the first year; only 2 males and 13 females developed hernia between the ages of six and twenty years. The greatest number of herniæ in the female occurred between the thirtieth and forty-fifth years.

In the normal infant the umbilical cord passes through an opening in the abdominal wall just large enough to transmit it. If this opening is unusually large, a bulging, due to increased intra-abdominal

[1] Statistics of London Truss Society, 1888–1890, and Treatise on Ruptures, Blakiston's Son, Philadelphia, 1893.

pressure is apt to occur, before closure of the opening by granulation takes place. As a result, an umbilical infantile hernia is formed. The coverings of such a hernia are peritoneum, subperitoneal fat, fascia, and skin. These hernia seldom attain a large size, and even in neglected cases sometimes close spontaneously. This spontaneous closure is due to the development of the abdominal muscles. These gradually increase in size and thus gradually obliterate the hernial opening. Such a favorable development of the abdominal muscles is not, however, to be depended upon. As soon as the protrusion is noticed, an efficient truss should be applied at once. A homemade appliance is quite sufficient. During infancy the best arrangement is to fix a pad over the umbilicus by means of a flannel binder. This pad should be quite flat and without a projecting knob. A projecting knob will keep the hernia reduced but will, by filling in the opening, prevent the same from closing. Great care should be used in the management of these pads. They must be kept dry and the parts scrupulously clean. When there is the least evidence of soiling they should be changed. At any event, they should to be changed once a day. In older children it may be more convenient to use a pad sewn in an elastic belt. If the above procedure is carried out it will rarely become necessary to advise an operation for this condition. Should such mechanical treatment, however, fail, operative measures should be undertaken which, in young children, are almost uniformly satisfactory. The operation to be described in the radical treatment of umbilical hernia in adults can readily be applied in these cases with but slight modification.

Adult Umbilical Hernia.—This has very little akin to the varieties above described. They usually occur in multiparous women, in whom the abdominal muscles have diminished in size and become relaxed as the fatty layers have correspondingly increased. On account of the enormous deposit of fat in the abdominal wall, these herniæ often attain a considerable size before they show any appreciable bulging.

The frequency of umbilical hernia in stout multiparous women materially raises the percentage of these herniæ in the female as compared to the male. Naturally they are most common between the ages of thirty and forty-five years, at which time an umbilical hernia in a man is very rare.

Etiology.—The cause of an adult umbilical hernia is an enormous stretching of the anterior abdominal wall, usually incident to pregnancy. In this condition there is usually a wide separation of the recti muscles and a stretching and thinning out of the fascia between them. Normally this fascia will withstand such a temporary stretching after which it again assumes its former relation to surrounding structures. If, however, the intra-abdominal pressure remains continously increased, as from lifting, straining at stool, or habitual coughing, the fascia will remain stretched. Add to this the fatty infiltration which goes hand in hand with the usual increased deposit of abdominal fat at this period of a woman's life and we have several factors, all tending to weaken the abdominal wall and predisposing to the gradual formation of a hernia.

Diagnosis.—The diagnosis of this variety of hernia is usually easy. It may be mistaken for a lipoma but a careful history will usually exclude a lipoma. A lipoma will have a gradual onset, but unlike an umbilical hernia is never reducible. In these herniæ early adhesions between omentum and intestines and hernial sac are quite the rule. When this occurs reduction may become impossible and the whole contents may then at any time become strangulated, in which case symptoms of acute intestinal obstruction will overshadow the less severe and more chronic symptoms the simple umbilical hernia occasions. Gastric disturbances from a lipoma are unheard of, while the gastric disturbance from an umbilical hernia are common and may even be the sole complaint for which the patient seeks relief.

Treatment.—There should be but one treatment of an adult umbilical hernia. Wearing abdominal belts with pads, various kinds of trusses, etc., may give some relief but will never cure an adult umbilical hernia. As mentioned above, infantile hernia may disappear spontaneously, or at least by means of mechanical appliances, but for adult umbilical hernia the reverse is true. These herniæ will increase in size until they become so large that their closure will tax the skill of even the most expert surgeon. In fact they will become so large that the great risk to life the necessary operative procedure entails renders them practically inoperable. The ideal method of treating these herniæ is therefore to operate upon them early. If this could be done in each case, 100 per cent. of cures could be assured.

The fate of most large umbilical hernia is strangulation of the hernial contents. The strangulated contents may consist of one or two loops of small intestine or the strangulated mass may embrace the greater part of the small and a considerable portion of the large intestine, especially the sigmoid and transverse colon. The treatment of such a condition is, of course, operative, but these patients can withstand very little operative interference. By the time they come to the surgeon, intra-abdominal pressure from tympanites is considerably increased and any operation that tends to relieve the strangulation and at the same time cure the hernia will also tend to increase the tympanites. In these cases we prefer therefore to simply relieve the obstruction. Besides this, if the intestinal coils are immensely distended and congested, becoming gangrenous, or if the patient has been vomiting continuously, we prefer to perform a temporary enterostomy at the same time. The repair of the hernia is left for a secondary operation. By this procedure we believe we have saved the lives of some patients, who surely would have succumbed, had the radical operation been attempted.

The great danger of operating upon the large uncomplicated umbilical hernia is the increased intra-abdominal pressure the operation produces. Murphy[1] claims: "You put the piston of respiration, which is the diaphragm, out of commission. The contracting dia-

[1] Murphy's Clinics, August, 1914, p. 863.

phragm is held voluntarily in abeyance because its movements increase the tension on the abdominal stitches and cause pain. Therefore the diaphragm makes shorter and shorter excursions, still further embarrassing the circulation already compromised by the increased abdominal pressure produced by the overlapping flap operation and postoperative tympanites. Finally the patient develops a hypostatic edema of the lower lobes of his lungs and soon dies as if by drowning."

Keeping this point of increased intra-abdominal pressure in mind, it is well, especially in the reducible hernia, to accustom the patient to the increased pressure several days before the operation. This can be done by keeping the patient in bed, reducing the hernia and keeping it reduced by some mechanical appliance. During this time

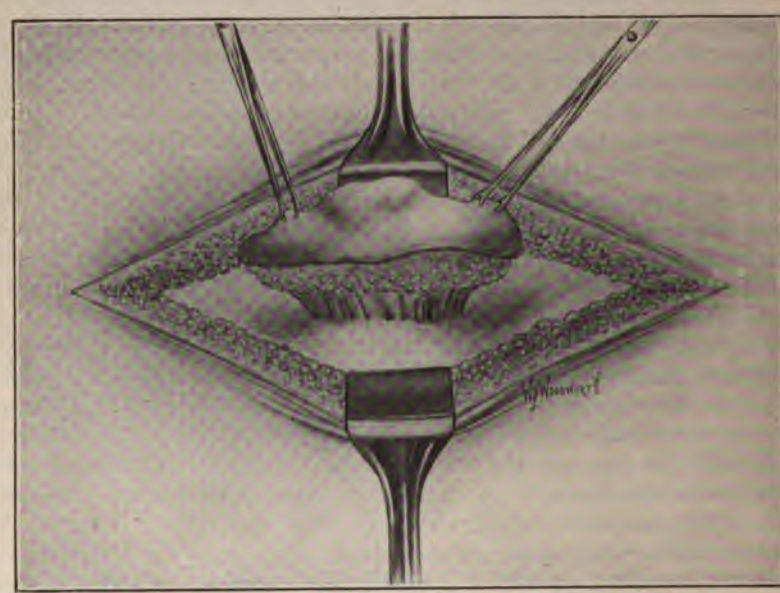


FIG. 57.—Umbilical hernia. Excision of sac and overlying skin. (After Mayo.)

the intake of food can also be limited and elimination by the bowel encouraged. This we have done in our cases of very large umbilical hernia and believe it has been of great value in preventing that extreme postoperative embarrassment of the circulation and respiration, so frequently seen after an operation for this condition, when undertaken without such preliminary preparation.

As for the operation itself, we believe that the Mayo[1] operation devised about eighteen years ago is the best. Two large transverse crescentic incisions are made about or near the base of the hernia (Fig. 57). The hernial sac is then opened. Adherent omentum is not dissected away but simply ligated and replaced in the abdominal cavity. Adherent bowel is freed and it too, replaced in the abdominal cavity.

[1] Jour. Am. Med. Assn., July 25, 1903, p. 225.

The hernial sac with its adherent omental stumps and skin is now excised *in toto*. Formerly, Mayo next separated the peritoneum from the under surface of the upper fascial flap. The lower fascial flap with its peritoneum was slipped into the pocket thus formed and held there by mattress sutures of either chromic catgut or celluloiden linen. Before these mattress sutures were tied the peritoneum was closed by a running catgut stitch. This procedure gave excellent results but as early as 1907, at the suggestion of A. J. Ochsner, separating the peritoneum from the under surface of the upper flap was entirely abandoned as quite an unnecessary and time-consuming dissection. Now, without

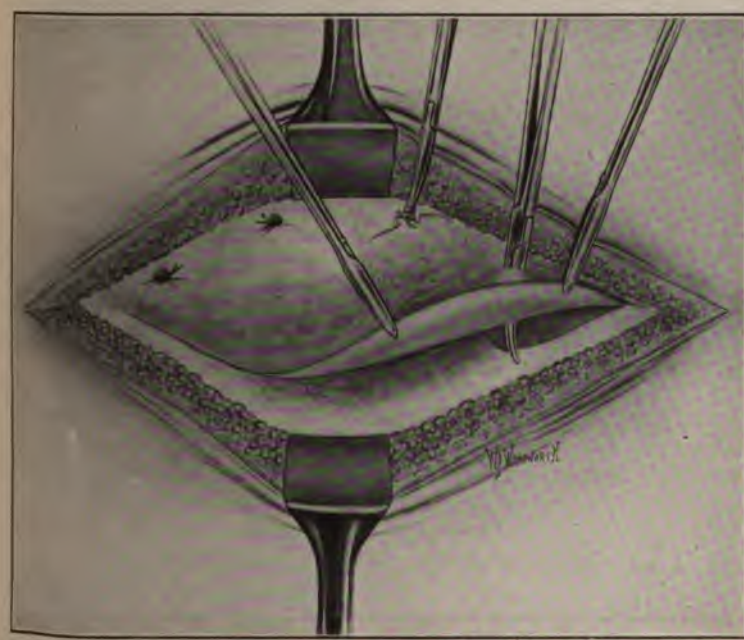


FIG. 58.—Umbilical hernia. The sac has been excised; the hernial ring widened by two lateral incisions. The lower flap of peritoneum, muscle and fascia is drawn up under upper flap by pointed forceps which have been passed through upper flap, two or three inches from its lower margin.

separating the peritoneum, the lower flap with its peritoneum is carried under the upper flap and held there by a row of mattress sutures of chromic catgut. The free margin of the upper flap is next fastened to the fascia at the level in which it naturally falls. The completed operation therefore brings the peritoneum of the upper flap in contact with the anterior surface of the fascia of the lower flap.

This operation is much simpler than the original operation and the permanent cures obtained therefrom are in all respects as good. The superficial fascia and skin are finally approximated in the usual manner.

Following the technic we have been employing in overlapping the aponeurosis of the external oblique in inguinal hernia, we have been

employing the same procedure in overlapping the fascia in umbilical hernia. This consists in piercing the upper fascial flap with a rather pointed forceps, two, three or four inches from its margin (depending upon the size of the flap at our disposal) (Fig. 58). The margin of the lower flap is now caught in the bite of this forceps and pulled up through the small opening made by the forceps, as it were, knotting the fasciæ at that point. The knot is fixed by a few over-and-over stitches of chromic catgut. The same method is used in fixing the margin of the upper flap (Fig. 59).

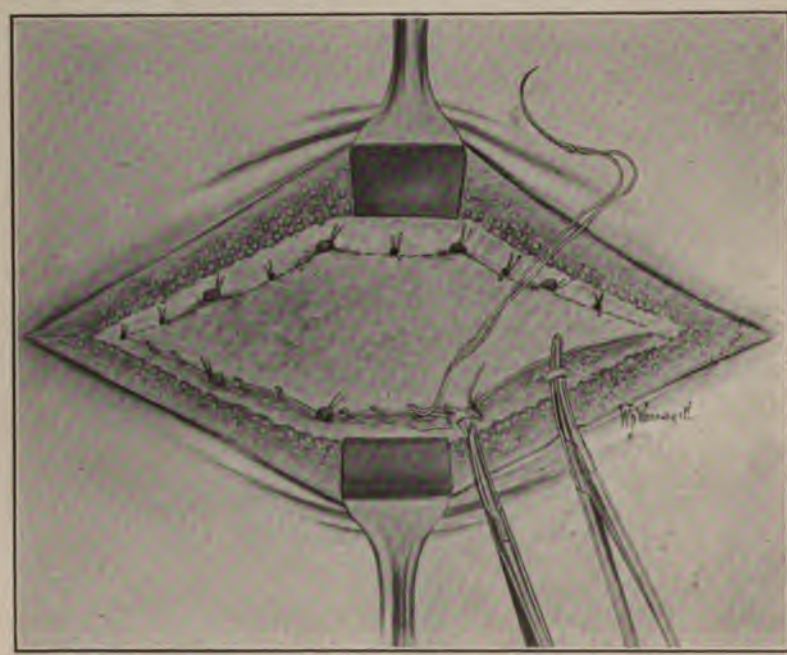


FIG. 59.—Umbilical hernia. Upper row of interrupted chromic catgut sutures, anchoring lower flap under upper flap have been tied. Margin of upper flap is buttonholed into fascia of lower flap, two or three inches from its margin by four or five interrupted chromic catgut sutures and further secured by a running suture.

If the adipose tissue in the operative field is excessive a considerable quantity of this is also removed.

Other operations have been advised for the cure of these herniæ but the only ones which are at all deserving of mention are those in which the "flap closure" is employed. Notably among these are the operations of Blake[1] and Graser.[2] The former uses a vertical overlapping from side to side and the latter, besides a transverse overlapping opens the sheath of recti muscles, sutures these together longitudinally and proceeds as in the Mayo operation. In our work we often have opened the sheath of the recti muscle, sutured them together

[1] Jour. Am. Med. Assn., 1903, xli, 225, and New York Med. Rec., 1901, lix, 803.
[2] Arch. f. klin. Chir., 1906, No. 2, vol. lxxx.

and used vertical flaps of fascia over the sutured recti muscles with uniformly good results (Figs. 61, 62 and 63). Such a procedure is well applicable to the smaller umbilical hernia; for the larger ones, however, we always use the flap from above downward, *i. e.*, the Mayo operation, and for these cases we believe this operation is unquestionably the best.

In the after-treatment of these cases there is nothing especially noteworthy except that the postoperative confinement in bed is longer than in the usual laparatomy (three to five weeks). It takes fully that length of time for tissues organically to unite and without a firm organic union, lapses will recur. Besides this, the patients are advised to wear for two or three months a well-fitting abdominal support. It is essential that this support have no pads or projecting knobs: simply, an even, slightly elastic support is aimed at.

VENTRAL HERNIA.

Under this heading we include all herniæ, except the postoperative ones, which pass through the anterior abdominal wall at a site other than at the umbilicus, femoral and inguinal regions. The most frequent site for their occurrence is at the linea alba and linea semilunaris. Even in the region of the linea semilunaris they are exceedingly rare. In the linea alba, those above the umbilicus are known as hernia epigastrica and those below as hernia para-umbilicalis. Considerable interest has been attached to the epigastric herniæ during the past few years. Moschowitz[1] and others claim they are not herniæ in the true sense, because they have no covering of peritoneum. He gives a rather ingenious explanation of their origin as follows: The linea alba lies next to the peritoneum except for the interposition of the transversalis fascia. Bloodvessels, running between the transversalis fascia and peritoneum pierce the linea alba and carry with themselves a prolongation of the transversalis fascia. This forms a weak point in the linea alba. It is at this point that epigastric herniæ develop. The fat, between the layers of the falciform ligament is nearest to this small opening and the increased intra-abdominal pressure forces it out, the peritoneum being behind the bulging.

Moschcowitz's theory explains some epigastric herniæ but it does not explain the formation of those epigastric herniæ which develop away from the falciform ligament of which we have had three examples. Some epigastric herniæ have, moreover, a peritonial covering, a true sac. The epigastric hernial opening in the fascia is usually a transverse slit, probably a congenital defect.

We have encountered three types of herniæ in this locality: (1) An opening through which is projecting a small mass of fat (probably the variety Moschcowitz has referred to). (2) A sac of peritoneum covered with a large amount of fat but empty and (3) a similar sac, in which the

[1] Surg., Gynec. and Obst., 1914, xviii, 504.

omentum was adherent. The symptoms in these cases ranged from practically no symptoms except a slight tumor to a dull dragging pain with irregular nausea and vomiting. As a rule these herniæ increase in size, they may attain a size as large as an orange or lemon at which stage they usually give considerable discomfort.

Treatment.—The treatment of this class of herniæ is very satisfactory. Trusses and other mechanical devices are as useless in this class of herniæ as they are for the adult umbilical hernia. They will not effect a permanent cure. The operative treatment which is really the only treatment is simple. It consists in excision of the sac if present, and a transverse overlapping of the edges of the slit in fascia. Our results in this class of herniæ have been perfect, not a single recurrence having come to our notice.

POSTOPERATIVE HERNIA.

A postoperative hernia is a protrusion of some of the abdominal contents through an imperfectly healed abdominal incision. On account of the more perfect closure of abdominal incisions and of early diagnosis and early operative intervention in suppurative abdominal disease, often eliminating the necessity of drainage, this condition is far less frequently found today than it was fifteen or twenty years ago. When present, it is usually the result of a weak scar from suppurative processes in the abdomen requiring drainage, with no or only partial closure of the wound; or it may result from a too rapid absorption of the deeper sutures with a gradual or sudden separation of the deeper parts; or it may be due to imperfect coaptation of the different layers of tissue at the time of operation. Statistics show that a hernia follows the "en masse" suture more often than it does the separate layer suture.

The gradual or sudden separation of the fascia and muscle that is responsible for the development of a postoperative hernia is usually a wide gap, so that the base of the hernia or hernial ring is large. As a result, strangulation of the hernial contents is rare except in old cases, where sacculation has taken place. The strangulation does not take place at the hernial ring but in one of the smaller rings at the entrance of a sacculated portion of the hernial sac. The coverings of these herniæ vary. Sometimes they are identical with those of an umbilical hernia and again, when instead of a stretching, a tearing of the fascia and peritoneum has occurred, the only covering a hernia of this kind has is superficial fascia and skin or a stretched and thinned out scar. In such a case the abdominal contents lie directly in the superficial fascia or are directly in contact with the skin scar. In this locality they usually become firmly adherent.

The size of these herniæ may become enormous. Almost complete eventration has been observed in the large postoperative herniæ. Just recently a large postoperative hernia came to our notice in which a seven-months' pregnant uterus was in the hernial sac, its weight dragging same down over the symphysis pubis (Fig. 60).

Symptoms.—The symptoms of postoperative hernia may be *nil* and then again continuous, dull dragging pains with exacerbations of colicky pains, nausea and vomiting and signs of intestinal obstruction are not infrequent.

Treatment.—Prevention is better than cure, but we cannot always prevent these herniæ. We can, however, prevent these herniæ from becoming very large and practically inoperable. If, after acute appendicitis, with prolonged drainage or after a drainage operation for some other cause or even after an operation in which there was no

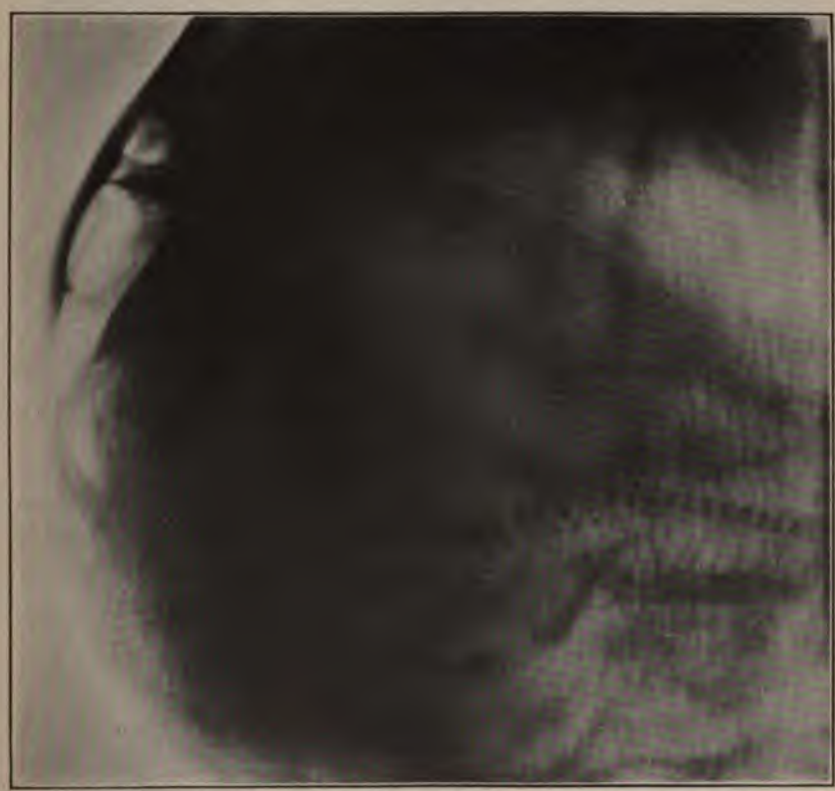


FIG. 60.—*X*-ray of a patient in whom the pregnant uterus almost completely filled the postoperative hernial sac.

drainage, the patient develops a bulging which at first may be no larger than a pigeon's egg, the time for operation is at hand. It is useless to try and improve the condition by trusses or supports. Even with these, the hernia will surely increase in size and sooner or later will become a hindrance to a comfortable existence. At a late date its repair will not only mean one of the most difficult and trying operations in all surgery but will also be serious on account of the many complications that may then affect the final result. The mortality in large ventral herniæ is high, whereas the operation, when the hernia is the

size of a pigeon's egg, is comparatively simple and at this time there is practically no mortality.

In repairing these herniæ, the different layers are dissected out and reapproximated with extreme exactness, as shown in Fig. 61, 62 and 63, or the operation of Mayo advised for umbilical hernia may be performed.

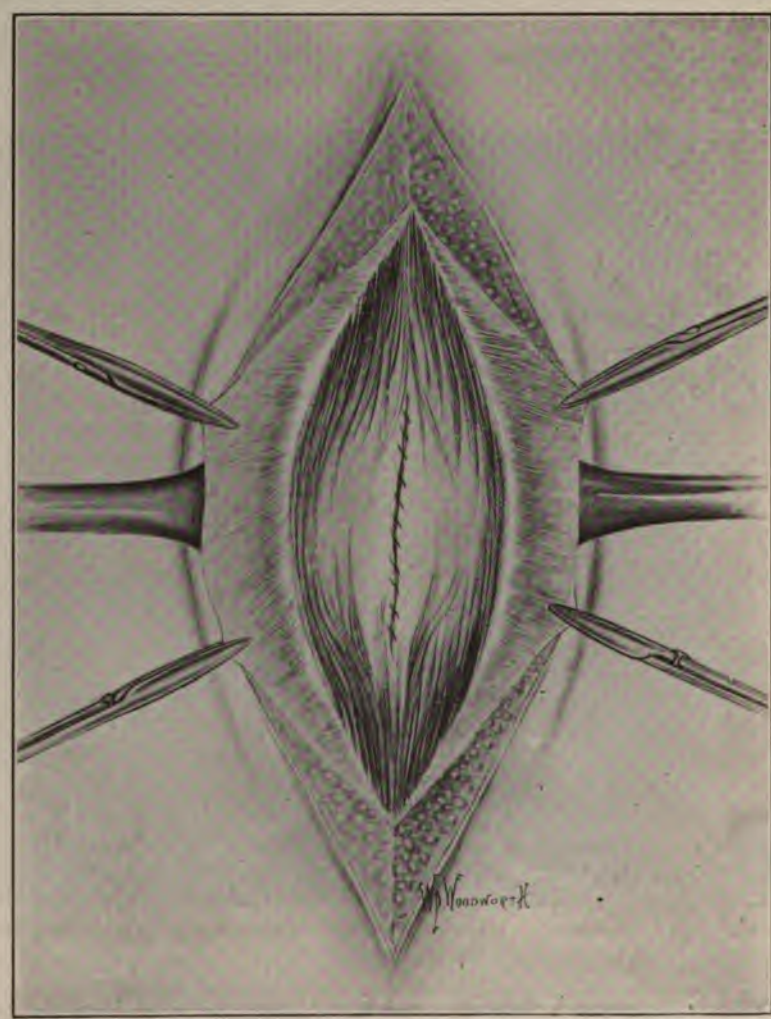


FIG. 61.—Postoperative hernia. The hernial sac has been dissected out and excised. The margins of the peritoneum sutured together under the rectus muscle.

The question, what should be done with the very large postoperative herniæ is still far from settled. If the operative risk is not too great, we believe in attempting a cure by a radical operation. If we follow the untreated cases or cases treated by abdominal belts, we find, that a large proportion, sooner or later become strangulated and then the

operative risk is increased tenfold. We prefer therefore to assume a slighter risk and give these patients a chance to live in comfort. The carefully followed cases in which the overlapping operation of Mayo has been used, has proved, beyond a question of a doubt, that the large postoperative hernia can be permanently cured. Its technic is not

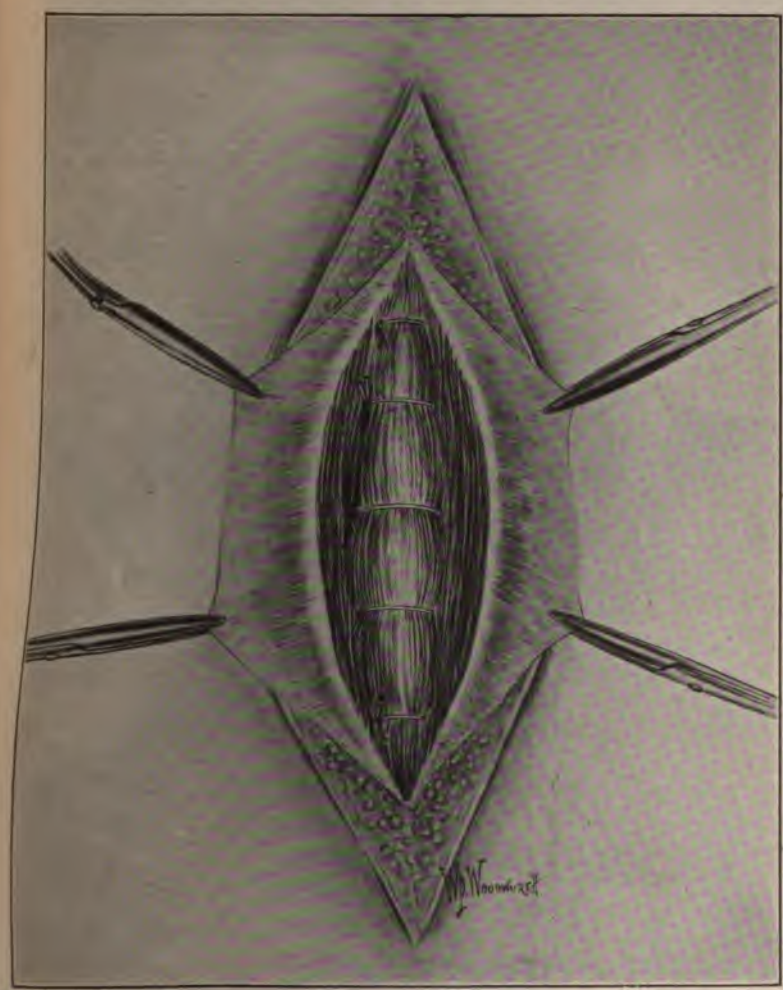


Fig. 62.—Postoperative hernia. The muscle fibers of the rectus abdominis muscle are brought together and sutured so with interrupted plain catgut.

difficult. The only real time-consuming part of this operation when applied to postoperative hernia is, freeing of adhesions of abdominal viscera to the sac or scar.

Of the other methods, the silver wire filligree of Bartlett[1] and the

[1] Ann. Surg., 1903, xxxiii, 47.

inversion method as advocated by Haynes[1] might prove helpful in some cases. The filligree of Bartlett consists in placing a filligree of No. 27 gauge wire, woven with numerous transverse strands and only

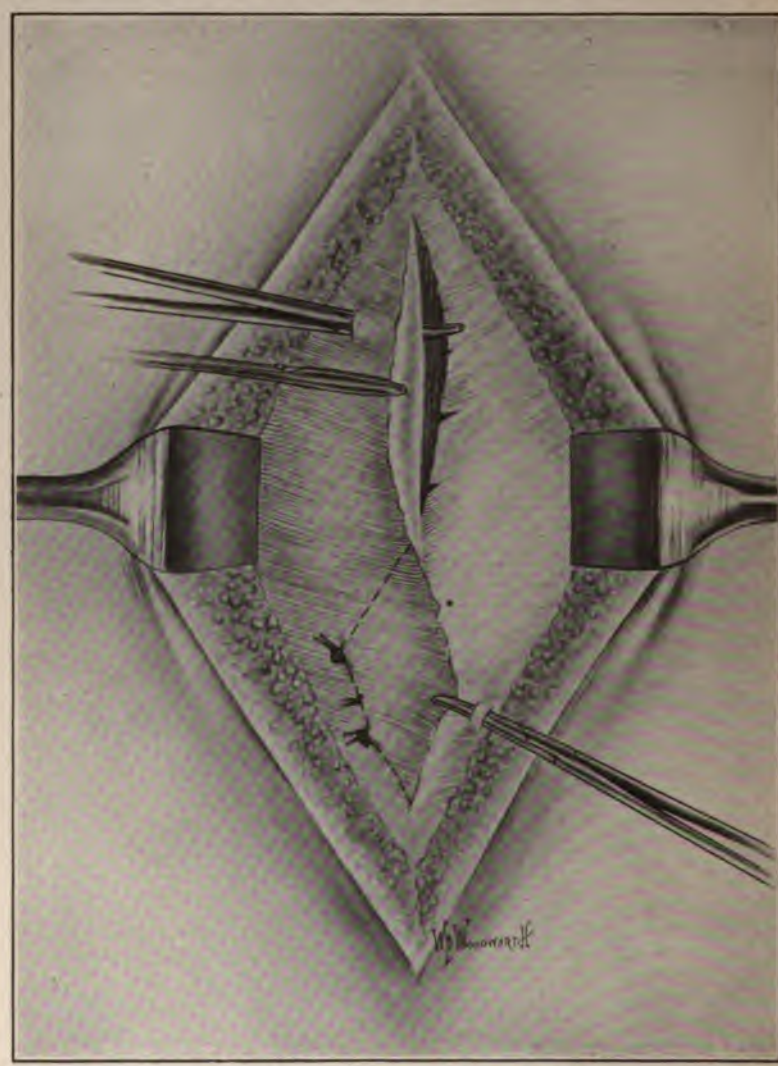


Fig. 63.—Postoperative hernia. The external sheath of the rectus muscle is overlapped longitudinally. Pointed forceps, piercing one flap about one or two inches from its margin, catch the margin of the other flap and draw the same up into small opening made by the forceps.

two or three vertical ones, between the peritoneum and muscle. This is overlapped for a short distance with firm tissue at its circumference

[1] New York State Med. Jour., 1913, xiii, 630.

and fixed in place with a few catgut stitches. With this method we have no personal experience. It never appealed to us and in the few cases in which we have seen it used it did not prove very successful.

The inversion method of Haynes might prove practicable in those patients who have large hernias and in whom operation becomes necessary, but who nevertheless cannot stand the prolonged dissection necessary for freeing adhesions, without great risk. This method consists in exposing the sac, inverting the same and keeping it so by carefully inserted sutures. Then, when the sac is infolded up to the hernial ring, the edges of the ring are approximated. This method does not remove the sac or even a part of it, nor does it free any adhesions.

At first sight, one would think that obstruction and strangulation would almost necessarily follow such a half-way measure, yet Haynes claims that such is not the case. In fact the largest herniæ treated in this manner have had really the least bowel trouble; the bowels have acted spontaneously on the second and third day. Haynes, however, does not advocate this procedure for all cases, but simply for those in which the operative risk would be too great if a complete dissection were carried out.

During the last five or six years successful transplantation of tissue has become an accomplished fact. It has been found that the success of the transplant depends primarily upon the blood supply; the tissues which normally have a meager blood supply are far more readily transplanted than those in which the blood supply is abundant. This principle has been applied to postoperative hernia and the fascia lata, which in all respects is a tissue of meager blood supply, has been used for the transplant. It is a tissue, which, in its new locality, will derive sufficient nourishment from the lymph which oozes about it until the newly developing bloodvessels can amply supply it with blood. Mann,[1] through a 7-inch incision in the outer aspect of the thigh has secured two strips of the strong iliotibial band from just below the insertion of the tensor fascia femoris. The two strips excised for the transplant were taken one below the other. They were three inches long and a little over two inches wide. These strips were then sutured transversely across the hernial opening, previously strengthened by plastic fascia flaps. They were sutured transversely, because the transverse direction is the one in which the lines of force in the natural pull on the abdominal muscles is exerted and it had been found, that if fascia is transplanted and is not kept on a stretch, it will shorten and become more or less replaced by fibrous tissue.

The fate of transplanted tissue, especially of fascia, is fairly well determined. With proper technic it is almost uniformly successful.

Fascial transplantation, in very large hernia, marks a great step forward in the operative treatment, although, at the present time it is too early to say definitely in which cases it should be used instead of or in conjunction with the universally adopted methods.

[1] Ann. Surg., 1914, lx, 481.

ABDOMINAL HERNIA.

By E. WYLLYS ANDREWS, A.M., M.D., F.A.C.S.

The term hernia in this treatise may be confined to the abdominal varieties. In a larger sense the word includes protrusions from all cavities of the body, as of the lung or the brain, but these topics are discussed elsewhere. The predisposing causes of abdominal hernia include certain congenital deficiencies and certain natural characteristics of the abdominal cavity. It has more flexible walls and more movable contents and also its natural orifices are less protected than any of the other cavities. The large bloodvessels, the spermatic cord and the large digestive canals passing through the moving abdominal walls form weak spots through which the contained viscera have a tendency to escape under pneumatic and hydrostatic pressure. This we see in the diaphragm, the pelvic floor, the inguinal canals and the outlets of the femoral vessels.

Not only are the mechanical factors present which favor hernial protrusion in the normal abdomen, but certain individuals have congenital defects of the whole wall, as in Figs. 64 and 65, and of certain natural outlets, as the vaginal processes which should close or coalesce in fetal life. As to the mechanics of hernia, it must be remembered that its contents act like fluid or air in a closed sac; they press equally in all directions, downward through the pelvis, backward through the loin, forward through the umbilical ring, or any weak spot in the musculature, and almost equally upward through any natural orifice in the diaphragm or any wound or rupture of that muscle. It is not, then, gravity so much as pneumatic and hydrostatic pressure which causes abdominal hernia.

From the complex anatomy of the boundaries of this cavity we see what a great variety of hernias may occur through its wall. Some of these varieties, as of the duodenal fossa, of the foramen of Winslow, of the obturator foramen, etc., are rare and others, as the inguinal, the femoral, the umbilical, ventral, etc., are so common as to make up 99 per cent. of all the cases. The rarer forms of abdominal hernia are often not diagnosed except at operation and their chief importance is in the differential diagnosis from other forms of intestinal obstruction.

The great frequency of inguinal and femoral hernias and, to a certain extent, of the umbilical and ventral forms, makes their study of great economic importance. This is now recognized by all employers of labor and most departments of the civil service. About 6 per cent. of all males in the community are incapacitated by hernia for appointment in army, navy, police or fire departments; also, some other civil

service positions. Many large employers of labor, especially those having relief and hospital systems, now refuse to employ men so affected and this causes large numbers of them constantly to seek surgical relief in our hospitals and clinics. This has become almost burdensome in

FIG. 64.—Section of pelvis in eight months' fetus. (Enderlen and Gasser.)

FIG. 65.—Pelvis, inside view at birth, showing double congenital hernia. (Enderlen and Gasser.)

certain institutions where operations for the cure of hernia far outnumber all other operative measures. This is apart from the necessity for operations to relieve complications, as that of strangulation or incarceration, and also it may be said is a prophylactic against the necessity or danger of these complications.

Inasmuch as the operative cure of hernia has now been perfected and is a highly specialized branch of our technic, the results are so far in advance of former practice that the operation may be said to have no mortality apart from such accidents as strangulation, and also to have so small a proportion of relapses that recurrence is much less than 5 per cent. It follows that the public has become educated to the idea of having radical-cure operations done almost as a routine in average cases so that the surgical practitioner should be alert to cultivate this field and perfect himself in the modern technic.

INGUINAL HERNIA.

The anatomy of the inguinal region may be divided into two planes or segments, the inguinal-abdominal and the inguinal-crural regions. The inguinal-abdominal plane is a triangle bounded by Poupart's ligament below, the linea alba toward the inner side, and a horizontal line between the anterior spines of the ilia above. In this region the abdominal wall is made up of the following layers: (1) skin; (2) superficial and deep fascia; (3) aponeurosis of external oblique; (4) conjoined tendon, or internal oblique and transversalis muscles; (5) transversalis fascia; (6) subperitoneal fat; (7) peritoneum. These may be considered more in detail.

Skin.—This is thinner and more movable than above. It is supplied with hair follicles and sebaceous glands. Often it shows atrophic or discolored spots caused by the use of truss pads.

Superficial Fascia.—This is divided into two layers by a fibrous lamella sometimes so dense as to be mistaken for the deep aponeurosis. The fibrous bands in this paniculus are very strong over Poupart's ligament, at which line they draw the skin into a deep groove, the inguinal femoral fold, sometimes called the suspensory ligament of the groin. Fibrous bands also attach to the cribriform fascia, external ring and anterior rectus sheath. In the central or suprapubic portion there are yellow elastic fibers which merge with the covering of the cord and spread out into the scrotum, forming the suspensory apparatus of the sac continuous with the dartos. Velpeau states that this is the analog of the muscle found in some animals and calls it the *ventrier*. Sappey names it "the suspensory of the scrotum." Numerous lymph nodes are found in this area, and also the superficial vessels, especially the epigastric vein and artery and branches of the circumflex ilii and external pubic vessels.

External Oblique.—This flat aponeurosis is the tendon of the external oblique muscle which is inserted into the rectus sheath and transmits its powerful contractile force to the pelvis, groin and middle line. It

is so broad and strong in the inguinal region that it forms the most important layer of the anterior abdominal wall and has, therefore, an active and a passive function—that of a fascia and that of a tendon. The tendinous fibers running downward and inward interlace and reinforce each other in the middle line, especially at the pubis.

The External Ring.—This is formed by the diversion fibers or pillars as they approach their insertion on each side of the pubis, leaving a triangular opening for the spermatic cord. This ring is 2 or 2.5 cm. in length and about half as wide.

The Conjoined Tendon or Internal Oblique.—Next beneath lie the internal oblique and transversalis muscle uniting in a single tendon to form the posterior layer of the abdominal wall. This is inserted into the rectus sheath, crest of the pubis and pectineal line. Fibers of this muscle descending in loops along the cord are called the cremaster. Through the layers of this muscle the spermatic cord makes its way to the point of exit at the external ring. In hernias it is often found that this layer is markedly deficient. It should be inserted nearer the whole length of Poupart's ligament, but in certain individuals, especially those with direct hernias, it fails to cover the posterior wall of the canal and no muscular floor is found in the angle between Poupart's ligament and the rectus sheath. This muscle is of importance to the surgeon since it is an important element in the plastic operation for the repair of hernia.

Transversalis Fascia.—The fascial lining of the abdominal wall is known as the transversalis fascia, a structure not to be confused with the conjoined tendon. Through this fascia, especially if viewed from the inner aspect, is seen an orifice giving exit to the spermatic cord. This is the internal abdominal ring, normally located 7 to 10 cm. upward and outward from the external ring. Thus the inguinal canal is formed by the passage of the cord obliquely through the layers a distance equal to that measured from one orifice to the other. In hernias in which this canal and these rings are much dilated, they enlarge toward each other until they may in some cases lie almost in line. In direct inguinal hernia the protrusion is not through the internal ring but through the conjoined tendon directly behind the external ring at the angle of Poupart's ligament and the rectus muscle.

Subserous Fat.—This is extremely variable in form and density. About the internal ring it is closely united to the peritoneum and often carries lobules of fat like lipomas. These may be lying free or firmly attached to the cord. They are sometimes of large size and simulate hernial protrusions. If overlooked they may cause apparent or real recurrence after operation and in some cases it is true that multiple sacs are found lying in the centers of lipomatous masses. Usually it is best to remove these pendulous masses by ligation, as they often contain bloodvessels. At my request Dr. Speed in the County Hospital made careful study of the lipomas found in 100 consecutive cases of our herniotomies, and found them present in 68 per cent. of all our operations. In a few cases no other hernial protrusion was found, yet these

gave the impulse, tumor and all the physical signs of inguinal hernia. We are decidedly of the opinion that they should be removed thoroughly at operation as they tend to produce recurrence by acting as a wedge and reopening a sutured canal. In the epigastric area the subserous fat is a very loose investment. The deep epigastric artery passes through this about 4 or 5 cm. outside the pubis. In this layer also are found on deep dissection the vas deferens and the spermatic vessels, uniting here to form the cord. In the prevesical or suprapubic region the subserous fat lies below the peritoneum rather than in front of it, the so-called Retzius space. Here it may happen that the bladder in the form of sliding hernia passes extraperitoneally into the tumor without any peritoneal sac.

Fig. 65.—External oblique muscle and external ring. (Enderlen and Gasser.)

Peritoneum.—No adequate idea of the peritoneum can be formed except by inspection from within. On looking at the anterior abdominal wall it is at once seen that this is not flat or uniform, but contains three depressions called the internal, middle and external inguinal fossæ (Figs. 66 and 67). The internal fossa is bounded by the middle line or urachus and the umbilical artery. The middle fossa lies between the umbilical artery and the deep epigastric vessels, and the external fossa just outside these vessels. The latter contains the vestiges of the processus vaginalis of the cord. In congenital hernias it communicates freely with the tunica vaginalis. In fetal life the testicle descends, carrying with it a process of the peritoneum and gives rise to the internal ring, not so much by perforating the fascia as by carrying it along as it advances. Thus its fibers may be said to form a complete tube or pouch along the cord and enclosing the testes.

Still looking from within, Hesselbach's ligament is seen to be a firm, crescent-shaped structure. The fibers form almost a "Z," the upper limb of which is Douglas' arch or ligament and the oblique line Hesselbach's ligament. Just outside of this the vessels, nerves and vas deferens unite to form the spermatic cord passing into the canal as one bundle.

As the cord passes through the canal its principle elements are the artery of the vas deferens, the spermatic artery, the anterior group of veins and lymphatics, the nerves and the vas deferens. On the tunica propria, or fibrous sheath of the cord, is often seen a small branch called by Bouveret the "funicular artery." The nerve lying along the anterior surface is easily identified as a whitish thread. In operations under local anesthesia this is easily infiltrated to produce anesthesia

FIG. 67.—Internal oblique muscle and canal. (Enderlen and Gasser.)

below. The vas deferens is easily distinguished from other vessels by its thick walls which give it the appearance of a solid cord. Varices and lobules of fat often lie along the cord and in certain cases of herniotomy should be removed at operation. In women the corresponding structure is the round ligament; its vessels are seldom enlarged or of surgical importance.

The canal, as a whole, is of triangular section, having an inferior, a posterior, and an anterior wall. For part of its course the cord lies between the transversalis muscle and the fascia, so that these layers may be said to be of the walls of the canal. Further down, the cord passes beneath the internal oblique and transversalis muscles, these structures being sometimes called the roof of the canal. At the lowest portion of the canal its anterior and posterior walls are respec-

tively the external oblique aponeurosis and the conjoined tendon, and the floor of Poupart's ligament and crest of the pubis.

Etiology.—Much discussion has occurred on the problem of trauma as opposed to congenital defect in the causation of hernia. This has been made a subject of controversy in connection with problems of accident insurance and personal injury suits for damages. Many pathologists take the ground that all hernias are of congenital origin. To support this view it can be shown that the affection is markedly hereditary, that a large number of adults who acquire hernias are found to have had the same affection in childhood, and that upon operation a great proportion of them prove to have the congenital preformed sac which clearly brought on the condition. On the other hand, trauma, when it can be proved, is usually found to have been some minor injury, as in lifting, or some unimportant strain. Perhaps it is too much to assert that traumatic hernia apart from congenital defect never is produced in the inguinal or femoral region, but very few cases can be discovered in which the history of injury is unmixed in this respect.

The pathological changes in hernia bring about marked structural alterations. With the exception of certain sliding hernias and the diaphragmatic forms, every hernia lies within a peritoneal pouch or sac. Usually this sac carries with it an investment of subserous fat and bloodvessels. Every sac has a body, or fundus, and a neck, but extraordinary variations occur in their form and size. Small and recent hernias may have no permanent sac which remains after reduction. Sometimes the sac is composed of thin, translucent peritoneum and at other times has hypertrophied inelastic walls from trophic disturbances. The neck of the sac usually has a condensed fibrous ring marked by a hard white line on its inner aspect. This is inelastic and is the point of compression in strangulated hernia. In congenital hernias a slender sac exists in advance of the descending hernia and this may be filled with fluid, like a hydrocele. Inflammations of the sac or its contents may cause the hernia to become adherent and irreducible, or produce hour-glass constrictions in its course so that there appear to be several rings, one below another with dilated pouches between. This appearance is often seen at operations and sometimes it appears to be due to the former neck of the sac having been dragged or pushed further down, allowing a new one to form above. Diverticula sometimes occur, giving the appearance of double or multiple sacs. These are important as the operation for radical cure may be a failure if any one diverticulum or pouch is overlooked.

It is important to remember that absence of the hernial sac is seen in certain types of hernia of the groin; namely, the sliding hernia, or "*hernia par glissement.*" These are produced by the sliding downward of the bladder or the colon retroperitoneally. Thus these viscera may be either enclosed in a peritoneal sac or devoid of sac, or both conditions may appear in the same hernia. It is important to call attention to this condition in order to warn against the danger of opening such organs by mistaking them for a peritoneal sac.

The hernial opening or ring, as mentioned above, is formed by an opening through the transversalis fascia. It is this ring which gives the name to various types of hernia anatomically different in location. Thus in the inguinal canal we have inguinal hernias, in the femoral canal femoral hernias, and in similar manner hernias are named after the regions in which they occur—as umbilical, ventral, lumbar, obturator, etc.

The contents of a hernial sac vary somewhat with its anatomical location, but in general the most mobile viscera, as the omentum and small intestines, are most frequently found. Next to these in frequency we find the large bowel and stomach, the bladder, uterus, tubes and ovaries, and least commonly of all the solid viscera—the liver, spleen, etc. Omentum retained in a hernial sac is often changed in appearance, becoming edematous and even hypertrophied. It is difficult to distinguish during operation between omental masses in the sac and the condition of lipoma mentioned above. This has sometimes been called "hernia adiposa." It is usually an accompaniment of hernia, and not an independent condition.

INFLAMED AND STRANGULATED HERNIA.

An accidental strangulation followed by inflammation and often gangrene of the contents is the most serious complication to be feared in these cases. In general the symptoms of this dangerous complication are those of acute intestinal obstruction; constipation, vomiting rapidly becoming fecal, collapse, and signs of peritonitis appear rapidly. In a very few hours the condition becomes dangerous to life. Unless early reduction is obtained, gangrene and perforation of the bowels occur and the patient suffers from septic intoxication and soon from general peritonitis.

Treatment.—In the treatment of strangulated hernia it is not always operative at first since some cases may be relieved by medication or by taxis. Gussenbauer and Finkelstein report cases relieved by spraying or washing the hernial tumor with ether and by the application of ice. Other measures that may be employed as an aid in practice are the rubber bandages applied around the tumor, sometimes over the hands of the operator to assist muscular efforts. Posture of the patient may assist reduction. When the hips are elevated gravity diverts the blood current and fecal flow, and the dependent viscera draw the intestines toward the diaphragm. The important treatment is that of reduction which should be attempted at first by taxis. This is not so simple and innocent a measure as has been supposed. Reduction of inflammed or devitalized intestine or of the whole sac, including the constricted neck, may do harm instead of good. Therefore efforts at taxis should only be used early and should not be too long continued or too forcibly applied. To accomplish reduction by taxis general anesthesia is sometimes needed. The pressure of the hand should be broadly and gently applied so as to compress the hernial tumor from all sides, and to pull or lift it away from the ring while exerting the pressure rather than to push or crowd it against the orifice. Gentle pressure long continued is more apt to accomplish reduction than sudden

or irregular force. In successful cases the first encouraging sign is generally a gurgle felt or heard—this noise signifying that something has passed back into the abdomen; and this something is more likely to be the air or fluid in the intestine than the latter structure itself. It is, however, a favorable sign, especially if repeated in the course of a few moments. After several repetitions of this gurgle of reduction it will usually be noted that the tumor decreases in size, and not uncommonly it slips back at last suddenly, like an ordinary reducible hernia. Such taxis requires great gentleness and skill, that can be acquired only by practice.

Operative Treatment of Strangulated Hernia.—Herniotomy formerly meant little but operation for strangulation, and special means and special instruments were employed which now should be completely abandoned. The operation at present should in no way differ from that described below for radical cure, except that the later stages of closing the rings may be omitted in very urgent cases. The use of probe pointed knives and long "hernia directors" for the purpose of dividing the constricting ring through narrow incisions is wholly to be abandoned, since the larger incisions are a safeguard rather than a danger in this work. The complications, as that of infection or gangrene of the intestines requiring resection or anastomosis, are best understood from their discussion in other sections in this book. Herniotomies for strangulation may usually be completed as radical-cure operations, since this adds but a few moments to the time of operation and anesthesia, but as these operations are often best performed under local anesthesia, and as there may be severe shock and bad local infection, it is sometimes better to close the wound hurriedly with a light tamponade to secure free drainage. In a sense, the occurrence of strangulation is a reproach to surgery. It should never occur when palliative or curative treatment has been properly employed. To prevent such accidents the proper support of hernias by trusses has a legitimate field and here much discretion is to be urged upon those advising and using trusses, lest they be employed in unsuitable cases or in an inefficient manner.

Trusses and Supports in the Treatment of Hernia.—In many adults and in most young infants the use of trusses becomes necessary unless operative cure is preferred. It is in infants especially that we may hope for recovery under truss treatment alone. This is only in the infant, the further step in the process begun in fetal life, namely the obliteration of the vaginal process. In the first year or two of life many hernias, disappear spontaneously but as the early natural time of closure passes the chances of spontaneous cure grow less constantly up to adult life, when very few permanent recoveries take place. For the infant one of the best supports is the yarn truss, a simple skein of yarn applied as a spica to the groin with a large, soft knot over the hernial ring. When spring trusses are used on infants it is well to have them encased entirely in vulcanite or celluloid so that bathing of the patient involves no uncleanliness.

Both for infants and adults the standard form of spring truss will give the most satisfaction in inguinal and femoral hernias. Most

FIG. 68.—Spring truss.

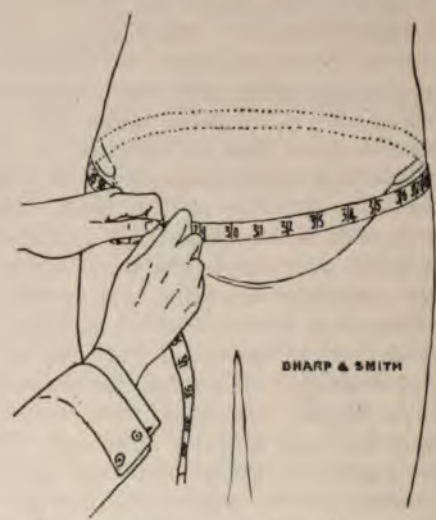


FIG. 69.—Measurements for spring truss.

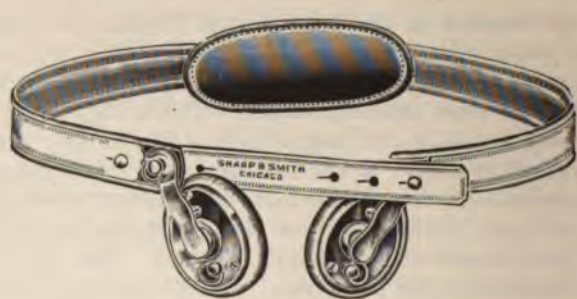


FIG. 70.—Double spring truss.

manufacturers keep graded sizes in stock with large varieties of pads, some large and some smaller, some soft or inflated with air, and others

hard, made of ivory, vulcanite or metal. The measurements usually required in ordering such appliances are the size of the ring and the circumference of the hips just below the crest of the ilium. Difficult cases frequently require the trial of several types or forms of spring trusses, or occasionally the construction of special belts or girdles, but when typical spring trusses do not readily hold the protrusion in place, it is usually better to advise radical operation rather than makeshift supports which cause discomfort and involve a risk of accident.

FIG. 71.—Belt truss for ventral and umbilical hernia.

FEMORAL HERNIA.

The inguino-crural triangle is separated from the inguino-abdominal, as above stated, by Poupart's ligament. In its upper part, which lies along the course of the great bloodvessels, are found the femoral or crural hernias.

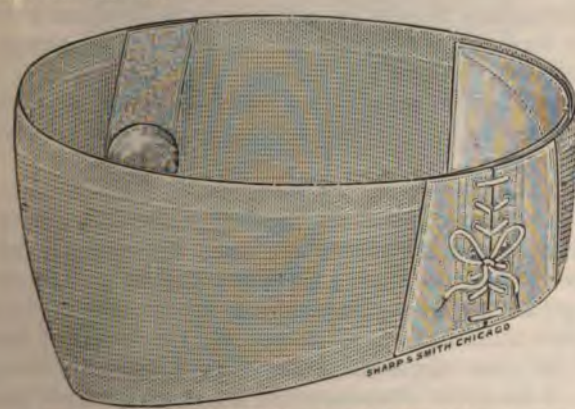


FIG. 72.—Combined belt truss and abdominal supporter.

The etiology of femoral hernia is less perfectly understood than that of inguinal hernia. The part played by a congenital defect of the sac or ring is not commonly recognized. Some modern writers, as Wuellstein, deny that femoral hernia is ever congenital or that it occurs in early life. On the other hand, many observations give weight to the claim that abnormal peritoneal tubes or pouches do sometimes appear along the track of the vessels, and that these abnormalities are congeni-

tal mesoblastic prolongations in fetal life. The occurrence of a scrotal femoral hernia, or the finding of the broad ligament in a femoral canal, points to the probable participation of an embryological factor in the production of some of these hernias.

Anatomy.—The anatomical layers are the same externally in this form as in inguinal hernia, namely, skin and external fasciæ. Lymph nodes are more numerous, as are also venous branches in the subcutaneous fat. The deep fascia, in this space the fascia lata, is perforated by the saphenous opening or ring, the concave margin of which, the falciform process, is crossed at its lower part by the long saphenous vein as it enters the saphenous opening. The fascia lata in front and Poupart's ligament are connected by fascial processes with the pectineal fascia and muscle and the ilio-psoas muscle behind. These fascial planes guard the great vessels, the external iliac vein and artery, as they lie in Scarpa's triangle, and tend to prevent the occurrence of hernia, either inside or outside the vein and artery, as the latter descend into the groin. Those fascial bands merge with Gimbernat's ligament on the inner side, practically closing the space up to the sheath of the vein. A similar band, which closes the space outside the femoral artery at its passage under Poupart's ligament, goes to the ileopectineal eminence; it is called the ileopectineal ligament. On neither side does adequate space for a canal exist normally, there being only sufficient room for one or two lymph nodes, called "Rosenmueller's glands."

The space in question, bounded by Poupart's ligament in front and the pectineal ridge and muscle behind, is sometimes called the "lacina muscularis." In addition to the great vessels it also transmits the psoas and iliacus musculo-tendon and the anterior crural nerve. It is filled also by loose adipose tissue and is closed by peritoneum, which, in normal subjects, is slightly hollowed or depressed, forming the fovea femoralis, which is analogous to the fovea inguinalis or slight dimple opposite the inguinal ring. This depression forms the starting point of a femoral hernia.

Pathology.—The peritoneum is forced into the femoral canal and thus forms a sac in the direction of the saphenous opening, out of which it passes to form a tumor under the skin. The hernia, when complete, has two rings—an inner small one at Poupart's ligament, and an outer larger one at the saphenous ring,—a space or canal connecting the two. This canal has for its outer wall the sheath of the femoral vessels, and the deep epigastric artery lies ordinarily to its outer side. On account of the great irregularity in the disposition of this and the obturator vessels, warning should be given against using any deep-cutting instrument, such as the probe-pointed herniotomy knife and the hernia director. Open dissection should supersede the older blind methods with their attendant danger of hemorrhage.

The wall of this canal and of the rings are incapable of great enlargement. Hence femoral hernias seldom attain large size, and as a consequence they are quite often overlooked. The rigid, small, and hard rings also cause strangulation to become more frequent than is the

case in inguinal hernia. The very small femoral hernias present difficulties in a diagnosis and may, if buried in the subcutaneous fat, be overlooked altogether. In case only omentum is in the sac, and if this becomes strangulated, the condition may easily be mistaken for an inflamed lymph node. In case of a strangulated intestine the obstruction may be attributed to the wrong cause, and so the hernia may remain undetected until it is too late to afford relief.

A double femoral hernia may occur in the same individual.

Diagnosis.—The differential diagnosis of femoral from inguinal hernia is made by the location of the former below Poupart's ligament; but, as the external tumor sometimes presses upward in front of the inguinal canal, it may occasionally be impossible to decide which variety is

FIG. 73.—Femoral hernia. (Andrews.)

present until the skin has been opened. Other conditions to be differentiated from femoral hernia are normal and inflamed lymph nodes. One reason for this similarity between the two conditions is to be found in the fact that many of the femoral sacs are small and have a globular form. Large varices about the ring, due to saccular dilatation of the long saphenous vein, present the appearance of tumors which sometimes almost perfectly simulate hernial protrusions. These are reducible, reappear when the patient assumes the erect position, and give an impulse when he coughs.

OPERATIONS FOR RADICAL CURE OF HERNIA.

The very ancient origin of the cure of hernia by operation is well known. Both cutting operations and spring trusses were employed at the earliest historical period of medical science. The operation for

inguinal rupture was rather common in medieval times, especially in France. Castration on the affected side was found to favor an easy solution of the problem of closing the ring, and this practice became so common that it was interdicted by statute on grounds of public policy.

In the period just before and just after the dawn of Listerism operations for the cure of hernia were devised by many clinicians, and it would be easy to find, in the treatises of from twenty to fifty years ago, accounts of scores of these methods, many of which bear the names of distinguished surgeons and are characterized by much ingenuity. Thus, in treatises which are still on our shelves, we may find the descriptions of operations known as the Wood, Wutzer, Heaton, McDowell, Ball, Nussbaum, Barker, Baxter, Czerny, and Woelfler operations,—not to mention a score of others,—all possessing more or

FIG. 74.—The femoral canal. The dissection shows the saphenous vein joining the femoral vein below Poupart's ligament. (Enderlen and Gasser.)

less merit and many of them still somewhat generally used. The drawbacks to all these methods are their comparative inefficiency and the greater risk that attends them. After abdominal surgery underwent its brilliant development, during the decade from 1880 to 1890, a new hernia era became possible and was indeed inevitable—an era in which all previous fear from opening the peritoneal cavity was abolished. This fear had been the most serious drawback to the development of a radical method of curing hernia, for it prevented free dissection of the structures involved and promoted half-way measures and makeshifts. The Wood and Wutzer operations avoided opening the skin by invaginating it with wire or silk sutures. Other methods —known as "sewing the pillars," etc.—contemplated only the closure

of the external ring. None of them sought to repair the breach in the wall from its deepest layers outward nor to make a very high extirpation of the sac. The canal, in these methods, was not widely opened; hence no true plastic operations could be done on its interior.

Nearly every later operation follows, of necessity, in the general lines of the Marcy-Macewen-Bassini technic. They differ from the Bassini method as much as from its predecessors, but, on account of the wide use and great prestige of the Italian's method, all later operations are often classed as modifications of it. Thus we read of the Bassini-Fournel operation in France—a procedure which is identical with the Andrews operation, but was published some years later; of the Bassini-Girard method in Switzerland—the same operation, probably independently devised; of the Bassini-Andrews method—also the same as the two last-mentioned, and published some years in advance of either.

Other divergent methods, such as Kocher's Verlagerungsmethode, Phelps' method of employing wire coils, and Willy Meyer's use of filligree, are relatively little used, or are used only in exceptional cases.

Technic of Bassini's Method.—Step 1. The canal in this operation is split along its whole length, after the skin has been divided, so as to afford access to the internal ring.

Step 2. The hernial sac is next sought and freed until it can be separated from the margins of the inner ring, and even a little higher up or deeper down; no portion even of the neck of the sac being permitted to remain behind. After the sac has been opened and its interior has been inspected, it is extirpated, if empty, by transfixing and ligating its neck at the highest possible point. The aim should be to leave no portion long enough to form even a dimple or funnel leading into the false opening.

Step 3. The next and most important step is the plastic obliteration of the false opening by means of a row of stitches which shall close the deep layers or posterior wall of the canal, at the spot where the false opening was barely large enough to transmit the cord. The latter should be relieved of all masses of adipose tissue, in order to reduce its size. The position and number of these deep stitches depend upon the size of the ring and the direction of the enlargement. They usually seem to restore the anatomy of the canal in the most effective manner when they are inserted internally to the deep ring, that is, between it and the pubis. The dilatation or stretching of the ring rarely or never takes place in an outward direction, but practically always inward. In Bassini's operation the cord is lifted out of the way and the stitches are placed behind it. The needle is passed through the internal oblique and transversalis and an effort is made to include also the transversalis fascia, which actually forms the internal ring. Followers of Bassini are apt to forget the importance which he attaches to this step, and to include muscle only in this stitch. Bassini, in operating, pushes a flat director into the inner ring next the peritoneum. With this he lifts all the structures except peritoneum,

to insure their being caught by the needle. The needle is next carried down behind the shelving edge of Poupart's ligament (seen on its inner

FIG. 75

FIG. 76

FIG. 77

FIGS. 75, 76 and 77.—Steps of the Bassini operation. (Bouveret.)

aspect in the lower side of the canal) and brought out through the ligament. The needle being passed from within outward, the vessels

are not endangered. If the reversed direction is used in passing the stitch, extreme care must be taken to prevent the needle point from injuring the femoral vein and artery. This accident has been reported several times. It can be avoided by placing the finger between the vessels and the ligament. The latter may then be pulled forward a little; after which the needle point is caught on the finger tip and guided into the canal. In doing this the operator rests the back of the finger upon the great vessels and is thus able to feel distinctly their pulsation. From two to five interrupted stitches are placed in this manner in the posterior wall of the canal, the cord being held temporarily to one side. The lowest of these stitches should be placed very near the pubic end and should include Gimbernat's ligament, if the deep hernial opening extends to its margin. The uppermost stitch should narrow the ring around the cord as much as possible without constricting its vessels. Bassini leaves the director above-mentioned in the inner ring, until this upper stitch is tied. It is then withdrawn, a little extra space being thus left for the cord. In doubtful cases the spermatic artery may be palpated before and after tying the upper stitch. If tying it stops the pulsation in this small vessel the stitch should be discarded. The occasional loss of a testis from gangrene after a hernia operation points to the need of care against too tight closure around the cord. At the same time it is important to narrow the ring as much as practicable, in order that the exit of the hernia may the more effectually be blocked.

Step 4. The next step in the Bassini method is the reuniting of the external oblique aponeurosis over the new canal or the reconstructed old canal. This may be done with continuous or with interrupted stitches. I have observed in Professor Bassini's own work that he places two interrupted stitches at each end, the intervening edges being brought together by a continuous suture.

Step 5. The final step is the closure of the skin. Bassini himself uses the form of suture shown in Fig. 77. This and all the deep sutures are of braided silk thread previously sterilized by boiling in glycerin. Most American and European operators use absorbable stitch material for the buried suture. Chromicized catgut is to be preferred. Plain catgut is not durable enough, as it lasts only a few days before it undergoes absorption; it is sometimes a cause of failure if used in herniotomy. Kangaroo tendon, the usefulness of which was discovered by Henry O. Marcy, is an ideal, durable animal ligature. It resists absorption longer than chromicized gut does- in some cases for as long a time as from four to eight weeks. I have used this exclusively for the deeper fascial suture in over 1400 herniotomies. Dr. W. B. Coley reports a large number of cases (2500) in which he has used it successfully in the Hospital for Ruptured and Crippled, New York City. The material is less well known in Europe than in America.

Merits and Demerits of the Marcy-Macewen-Bassini Operation.—The method just described is deservedly popular, safe, and rational, as well as easy of execution. Analyzing the elements which contribute

to this success we are impressed with the vital importance of two steps, *viz.*, the high extirpation of the sac, a step which was not original with Bassini, and, as a corollary, the open dissection quite up to the peritoneal layer. It was the failure to make this open dissection which marred the work of the earlier operators. They failed to perform a true plastic operation and tried to substitute various kinds of blind suturing. The failure to extirpate the sac high up caused numerous relapses or partial relapses, as when a scrotal hernia returned (or remained) as a bubonocele. Probably the simple removal of this sac would alone be sufficient to cure many small hernias without any suturing of the canal. As the muscles and the fascia are denuded by stripping out the sac, they would often fall together as well without stitches as with them, and might unite firmly under the pressure of bandages. Dr. A. J. Ochsner, of Chicago, has demonstrated that this is true in femoral hernia. It may be equally true of small oblique inguinal hernias. When, however, the rings are greatly enlarged, even the Bassini suture is difficult to place and of doubtful permanence. The inner margin of the dilated orifice then extends from Hesselbach's ligament, outer border of conjoined tendon, almost or quite to the rectus muscle. The internal and external rings are dragged into line so as to form an antero-posterior opening. On account of the absence or displacement of the conjoined tendon, the outer edge of the rectus sheath or muscle must be utilized in making the deep stitch. This drags the rectus outward and Poupart's ligament upward and inward, and even then one does not secure a good posterior wall for the canal. The principal element of a successful plastic operation, namely, a well-nourished flap, without tension, is wanting. Exactly the reverse conditions are found, *viz.*, a thin and poorly nourished flap under severe tension. These defects in the Bassini method obviously have impressed all operators when they encounter large rings. The need of something to supplement the defective anatomy is then at once evident. An ideal method would be one which supplied a well-nourished flap of such ample size that it could be brought over the weak spot without tension.

It is extremely interesting to note the unanimity with which this need has been felt—a unanimity manifested by the large number of the ingenious methods which have been suggested for the purpose. To enumerate a few of these: Halsted divided the rectus sheath and spread the muscular bundles out by attaching them to Poupart's ligament; Woelfler everted the anterior sheath of the same muscle, thus making a kind of trap-door flap which closed the rings when it was sutured over them; the anterior part of the fascia lata has been turned upward to form the same sort of flap; the tensor vaginæ femoris muscle has been dissected loose and turned upward to fill the canal; the scrotal skin and even the testicle have been invaginated to plug up the canal (measures which constitute in a certain sense a flap method); bone grafts (Weir), sponge grafts, and wire filligree have been inserted to meet the same indications. In this category should also

be placed the obsolete method of McBurney, who packed the hernial canal wide open, forcing it to heal by granulation so as to develop a large mass of scar tissue. These methods all introduce elements of risk and uncertainty, and none of them is now largely employed. It remained for the method of imbrication of Andrews to supply, in the treatment of inguinal hernia, the step needed to secure the object of all these difficult and ingenious methods without in anyway adding to the severity of the herniotomy or to the length of time required for its performance. This method was published in 1895 and subsequently by Girard, in Berne, in 1898, and by Professor Fournel, in Paris, in 1900, each writer apparently being unaware of the other's work. Lucas-Championniere had still earlier suggested doubling up of the abdominal layers, as had also Macewen, but this was more by everting than by overlapping the cut edges, and did not constitute true imbrication.

The Andrews Operation.—This herniotomy is done in fifteen or twenty minutes in simple cases. Two types of imbrication or overlapping—a posterior behind the cord, and an anterior, in front of the cord—are described in the original publication.[1] One of these has since been printed as the "Girard operation," and one as the "Hopkins' operation," with the statement: "This is called the Andrews operation, but we devised it independently."

Posterior imbrication appeals to those who like the Bassini method; anterior imbrication, to those who object to "transplanting the cord." It leaves the cord behind the deep suture line. There is a tendency of late to do more anterior operations, in which Dr. Ferguson of Chicago has been the pioneer. Dr. Coley of New York informs us that he uses both types, but rather more often the old-fashioned posterior method.

The minor details described below may vary with different operators, but should never vary with the same operator. Speed and smoothness come from uniformity, followed for uniformity's sake. Each operation becomes a rehearsal for the next. After this prologue we begin:

Step 1. *Skin Incision.*—Location 2 or 3 cm. above Poupart's ligament, parallel to its inner two thirds. Length 15 to 18 cm. in adults. Pinch a fold of skin transverse to the groin with the left hand, the assistant holding the same fold 3 or 4 cm. distant. Raise this fold 7 to 10 cm. and cut its whole height by one stroke of a large keen scalpel. Continue holding the pinched-up margins, relaxing slightly until the epigastric and other vessels are seen and secured. Then drop the skin and pick up every smallest bleeding-point. Do not allow even droplets of blood to continue running. Expose the external ring and aponeurosis cleanly.

Step 2. *Opening Inguinal Canal.*—Do not insert a director and split the ring up from below, but split the external oblique aponeurosis the length of the canal by one straight cut from above between its fibers. Evert the lower segment and run the scalpel handle along its inner aspect, exposing freely the shelving inner edge of Poupart's ligament.

[1] Chicago Med. Recorder, July, 1895.

Step 3. *Removing the Sac.*—Either lift up the cord mass on the finger, which requires some blunt dissection, or let it lie adherent, according as you wish to repair the ring behind or in front of the cord. In either case remove any lipomatous masses high up by tying off above the ring. Do not remove any veins or cremaster strings. Cut a buttonhole with a small, keen knife in the fascia propria of the cord until, at just the right depth, you see the pearly-white sac-wall. It is like a hydrocele dissection. Seize this wall with blunt forceps and

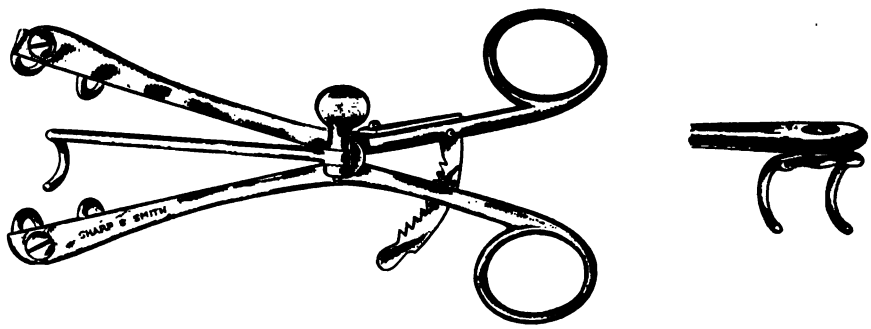


FIG. 78.—Andrews' hernia retractor with swinging suspensory hook for cord. Can be set at any height, and swung back and forth as the deep stitches are being inserted.

strip it rapidly out by sponging away the cord elements with dry gauze. Now and then strong adhesions are met, requiring nicking or cutting. In congenital hernias do not take time to sew a process of sac around the cord. Follow well up into the abdomen, and a place will be found where the cord and sac diverge, so that the sac-neck can be ligated without inclosing the vas or vessels.

In scrotal hernias strip out the sac, if easily separable. If not, cut off the part in the canal, and return the scrotal part to the scrotum, either with a gauze drain through the lower end of scrotal skin or else everted like a hydrocele operation. Pull the testis freely up into the wound whenever necessary. In several cases the scrotal sac formed a hydrocele, requiring subsequent tapping, but in many others caused no trouble. Separate the parietal peritoneum 2 or 3 cm. all around the ring with the finger, so that it is loose from the muscles and can be drawn down freely. Open the sac widely at its fundus and look very carefully all over its interior for adherent omentum or bowel, especially at its neck. Keep this opening under the eye up to the moment of ligating, and watch carefully that nothing slips into it. Simple ligature for narrow sacs, and suture ligature or purse-string closure for large ones, are the best. The Macewen pad of the folded-up sac has no great faults or merits. We sometimes use it in atypical large hernias to increase for a time the amount of new deposit at the weak point, but are somewhat skeptical of its permanent value. On account of the loosening of the surrounding peritoneum, the cut-off sac will retract well beyond the muscles. If the stump lies visible in the ring,

it is too long, and will form a funnel or dimple inside, tending to bring on another protrusion. If the stump does not disappear wholly, remove more of it.

Step 4. *Deep Suture.*—(*a.* Anterior imbrication.) Place from two to five strong stitches uniting the conjoined tendon and muscles together with the upper segment of external oblique firmly down to Poupart's ligament, all in front of the cord, which is thus pushed backward and toward the pubes. The lower flap of external oblique is left free for Step 5.

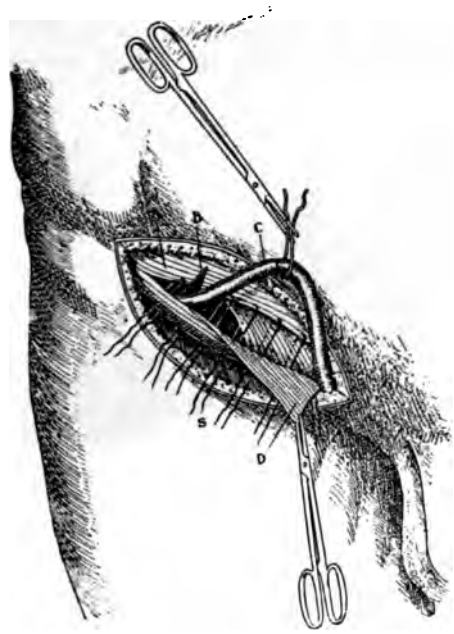


FIG. 79.—Andrews' operation. Mattress deep stitches, in posterior imbrication. *A*, external oblique; *C*, cord lifted; *D*, lower flap of external oblique.

(*b.* Posterior imbrication.) Lift up the cord on a loop of tape or Andrews' hernia-retractor, (Fig. 78), which holds the wound open and has an adjustable hook to suspend the cord. Pass the deep stitch behind the cord by first lifting Poupart's ligament on the left forefinger and pushing the needle from outside the fascia behind it. The needle point is guided by the forefinger and cannot injure the vessels. It is vitally important in direct hernias and large rings to get the first deep stitch as near the pubic end of the ligament as possible. It often includes a little of Gimbernat's ligament.

From its entrance point the needle is guided by the forefinger into the canal. It is then picked up and the opposing muscle entered from within outward. The lowest or first stitch in large rings should include a little of the rectus muscle, the sheath being split open to allow this. In small rings this is not necessary. Do not resort to the Woelfler

method of everting a trap-door flap of rectus sheath, or any other mutilating flap methods. The imbrication is of itself a perfect flap transplantation, and will fill the largest rings without great tension. After transfixing the transversalis fascia and conjoined tendon or muscles, we have what would be a Bassini stitch in mattress form. To this we now add the external oblique margin, either in the same loop or by passing the needle, which has already pierced the deep muscle, down and forward through Poupart's ligament and back to catch the external oblique. The needle is next passed out just in front of Poupart's ligament, so that it emerges about 5 mm. in front of where it entered, and surrounds the ligament. It is thus a mattress stitch, with the knot just inside the skin and fat of the groin. From two

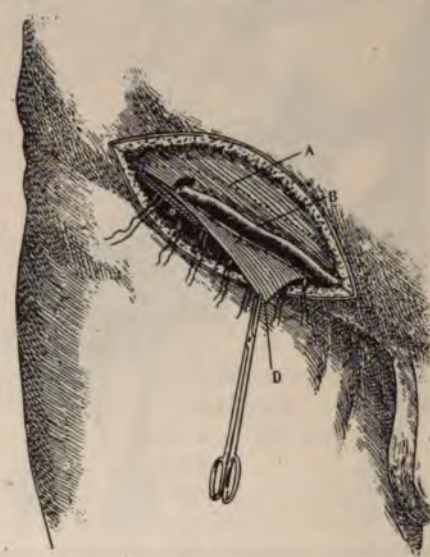


FIG. 80.—Andrews' operation. Deep stitches tied. *B*, cord replaced; *A*, dotted line showing where lower flap *D* will be overlapped.

to five such deep stitches are used. It is a mistake to place them very near together, or tie very tightly. The uppermost or outermost stitch should narrow the ring snugly around the cord. Tie this one first and watch the effect on the cord. Commonly, its artery can be felt pulsating before and after tying. If in doubt, discard the upper stitch.

Step 5. *Second Deep Suture.*—Lap the lower segment of external oblique upward across the upper. In case the cord has been raised, it goes between these layers. They overlap about 2 cm. at the external ring, thus strengthening and narrowing this dilated orifice. Suture them in this position tight enough to bear part of the strain on the deeper stitches by a lock-stitch running-seam. It will then be seen that the strength of the abdominal wall has been doubled by redoubling

its thickness; also, that these overlapped surfaces are more sure to unite firmly than in the edge-to-edge of other methods.

Step 6. *Skin Closure.*—After very thorough hemostasis, sew the skin with a trocar-pointed needle held in the fingers. The following form of buttonhole continuous suture will please those who have not seen it.

After the first knot, thrust the needle through both flaps about 1 cm. from their edges. With the skin thus transfixed, wind the slack of the thread twice around the point, instead of once, as in the ordinary lock-stitch. Then draw it up until it is just tight between the stitches, but does not pucker.

FIG. 81.—Andrews' operation. Step 5. Imbricated lower segment of external oblique.

There is no back-slip, and each stitch holds by friction. This gives a ridged-shaped suture-line like a double row of stitches. Why it does so, I cannot explain, but no other suture looks like it.

Do not drain these wounds, except in rare cases where there is much dissection and persistent oozing, when it is well to insert a small drain through an independent buttonhole—not through the angle of the incision.

Seal the wound with collodion. Firmly bandage both groins with wide spica bandages. In children and restless patients it is sometimes well to pad the hips, trunk, and thighs with antiseptic cotton, and put a light cast or starch bandage from the chest to the knees.

There is no advantage in redressing these cases. They are well on the eighth or tenth day, and should be allowed to be up and take ordinary exercise at once. Let no binder or truss be used after discharging the patient.

Treatment of Femoral Hernia.—Operative treatment is more imperative in femoral than in inguinal hernia because the liability to strangulation is greater, because the lesion itself is small and is therefore likely to be underrated as regards its importance, and because the results obtained by the use of trusses are so imperfect.

Some fifty varieties of operation for this affection have been published since 1879. These may be arranged in the following groups:

1. *Sac Extirpation.*—By ligation, by burying the stump, and by skin invagination. (Socin.)
2. *Suture Methods for Rings.*
3. *Plastic Operations to Implant Muscular Tissue.*—(Lotheissen, Cadivella, Parlovecchio.)
4. *Plastic Flaps.*—(Talzer) Fibrous or musculo-tendinous flaps. (Watson-Cheyne, McArdale, Maunsell Moulin, Swartz.) Periosteal flaps. (von Mikulicz.) Osteoplastic flaps. (Trendelenburg, Korte.)
5. *Heteroplastic.*—(Talzer, Schwarz, Thiriar.)

It is not possible to state which of these divergent methods has become best established. Nearly all mutilating flap operations or heteroplastic methods have been abandoned for simple suture at the rings after high extirpation of the sac. Ochsner asserts that sac extirpation alone, without suture, will cure all cases. There is good evidence in favor of this belief, since femoral rings are small and the sac denudation would leave surfaces well fitted to unite. All operations have the first step in common. Many authorities advise making a skin opening, over the ring, in the long axis of the thigh. An incision parallel to Poupart's ligament is, we believe, to be preferred. It gives access to the inguinal canal if such a step is desired. The sac lies underneath the skin and fasciæ and is often embedded in a firm layer of fat. The greatest care is needed to avoid injuring its contents if irreducible. A very thick wall should at once excite suspicion that it may be a sliding hernia of the bladder or colon, in which case no sac will be present. These viscera slide into the hernia below the peritoneal reflection and are often opened, by mistake, for the sac. When the sac has been identified and explored it should be detached, by blunt dissection, throughout the whole length of the canal, drawn down and amputated, or dealt with from above by opening the inguinal canal or abdomen.

The closure of the deep ring is theoretically possible by suturing Poupart's ligament to Cooper's ligament and the pectineal fascia. This is a step which seems unsatisfactory on account of the disparity between the structures united. It can be accomplished by two or three mattress stitches extending from the pubis to the sheath of the vein. Extreme caution is to be observed not to prick the latter with the needle.

The outer ring or saphenous opening is also narrowed by suturing the falciform process across and overlapping the fascia lata, great care being taken not to wound or constrict the long saphenous vein.

Operating Through the Inguinal Canal.—In Frank's method the sac is drawn out through the inguinal ring, ligated, and resected, the ends of the ligature being drawn out through the muscles at a point some distance above and then tied at this point. The tendency to hernia is then corrected by suturing the posterior margin of Poupart's ligament to the pectineal fascia and the periosteum of the horizontal branch of the pubis; after which, four threads are passed through the triangular ligament, so as to draw it up to the muscles above.

Roux's Nail Operation.—Roux fastens with a double-pointed nail the edge of Poupart's ligament to the horizontal ramus of the pubis as a radical means of curing femoral hernia. Since 1904 Hochenegg, in the Vienna Clinic, has applied this technic in 38 cases of femoral hernia, all but 8 of them women; general anesthesia being used in 33. The ultimate outcome—the interval of time since the operation ranging from six months to four years—is known in 28 cases. The results have been satisfactory in every respect, even in 1 case in which the nail was felt to be loose. The outcome, he believes, compares favorably with that obtained by other methods, while the simplicity of the operation commends it for certain cases.

OBTURATOR HERNIA.

The obturator foramen is closed by a strong septum, the obturator membrane, which is usually in two layers separated by light areolar tissue. The obturator internus and externus muscles, which spring from the inner and outer surfaces of this membrane, pass toward the trochanter major as external rotators of the femur. The obturator canal or sulcus permits the passage of the obturator nerve, artery, and vein in the order named, from above downward. This canal is normally less than 2 cm. in length and only large enough to transmit the nerve and vessels in their course through the obturator membranes beneath the horizontal ramus of the pubis.

Hernias through the obturator foramen appear in the front of the thigh not far from the location of the femoral artery, but at a somewhat greater depth or more posteriorly. Men are often less affected than women, and, in the cases belonging to the latter sex, it appears from the reports that the patients were of an advanced age, several of them beyond the sixtieth year of life. This may be explained by the facts that the pelvis is wider in women, that the bones are more tilted, and that atrophy and the deposit of fat are often observed in advanced age. Obturator hernias may be double or single and may contain either omentum or intestine. Cases are reported in which the hernial sac contained the tubes, ovaries, or the bladder.

Diagnosis.—On account of the small and deeply buried sac the diagnosis of obturator hernia may be difficult or impossible except when strangulation occurs. Palpation may give negative results except when made bimanually through the vagina or the rectum. With the bladder and rectum previously emptied it is possible to detect a cord-like mass leading downward to the obturator foramen. Another sign

that is usually present is retraction of, or slight loss of power to extend, the thigh. This is also a symptom of psoas and iliac abscess. One trustworthy symptom of obturator hernia is the Howship-Romberg sign. It consists of a neuralgias and a paresthesias of the obturator nerve. This symptom is easily marked when the hernia is under great pressure or is strangulated. The pain is referred along the inner aspect of the thigh to the knee or to a point a little below the knee, and sometimes to the region of the hip-joint.

Treatment.—The treatment of obturator hernia has given a high mortality. This is due to the late stage of the disease and the fact that the subjects were mostly aged, feeble women. Few or no cases have been operated upon except for strangulation. Under non-

FIG. 82.—Ischiatic hernia. (Enderlen and Gasser.)

operative treatment the results have been much worse, according to Schmidt. The operation of choice should in some cases, especially those in which the diagnosis is in doubt, be a laparotomy from above. The strangulated bowel can then be dealt with in whatever manner its condition calls for. For direct operations upon the hernia a vertical incision is made over the saphenous opening. The inner margin of the pectineus muscle is drawn outward after the fascia lata have been divided. It is sometimes better to divide the pectineus longitudinally by blunt separation of its fibers or to cut its origin partly from the bone. The sac is found between the ileopsoas and the adductor brevis muscles, it having passed the obturator externus muscle. More rarely it passes behind and below this tendon. The exploration and extirpation of the sac in this narrow space, without injuring the vessels and

nerves which lie against it, is a difficult operation. The location of the vessels may be made out by palpation, and, by the aid of this knowledge one may divide the constriction without injuring them. The outward direction of the cut aids greatly in warding off the possibility of this accident. On account of the danger of such a complication it is doubtless wiser to resort to a laparotomy, as mentioned above. Reidel advised the securing of a freer opening by resecting the pubic ramus, which forms the upper boundary of the ring.

ISCHIATIC OR SCIATIC HERNIA.

The sciatic notch is crossed by the great sacrosciatic ligament in such a manner as to form the greater sciatic foramen, an opening which is partly filled by the pyriformis muscle. Two spaces are left —one above this muscle and one below it. The upper space affords a passage to the superior gluteal vessels and nerve, and the lower one transmits the ischiatic vessels and nerves and the internal pubic vessels and nerves.

Treatment.—The treatment of sciatic hernia by any form of truss is not practicable. Few operations have been performed except in the emergency of strangulation. When one operates, the best course is to make the incision between the tuberosity of the ischium and the coccyx, in a direction parallel to the lower border of the gluteus maximus. This muscle should be bisected by a second upward cut, the two together forming a T-shaped incision. The gluteus medius must next be exposed and divided high enough to enable the operator to reach the space above or below the pyriformis muscle, according to the type of the hernia. The large size of the vessels encountered makes this operation often bloody and difficult. After a wide exposure and a careful hemostasis it is usually possible to isolate and remove the sac, and to place stitches in the muscular and ligamentous margin of the ring.

PERINEAL HERNIA.

Hernias in the perineum in men and women occur both independently and in association with prolapse of various organs (the anus, uterus, bladder, etc.). At the points where the natural outlets of these viscera (rectum, vagina, etc.), pass through the pelvic floor or partition, an opportunity is afforded for the development of a hernia. The natural pelvic orifices (urethral, vaginal, rectal), are perforations through the urogenital diaphragm, which latter may be defined as a central ligamentous septum of the pelvic floor, the lateral halves of which are composed of muscular tissue—*i. e.*, the two levator ani muscles.

Perineal hernias usually are central—that is, infrapubic—but they may, under certain circumstances, occupy lateral positions in one or the other of the ischiorectal fossæ.

Central perineal hernias usually appear, as their name indicates. The large hernias are commonly associated with some form of pro-

lapse occuring behind, in front, or to one side of, a prolapsed rectum, vagina or bladder. Accidents have followed the careless incision or attempted removal of hernial masses pressing upon these structures, in the erroneous belief that the masses in question were polypi or other growths.

Treatment.—In general, the treatment of perineal hernia by trusses or supports is unsatisfactory. A cure of the condition by operation is attempted usually in connection with plastic operations on the perineum or rectum, and is only an incident in this work.

LUMBAR HERNIA.

Hernia in the loin or lumbar muscles is one of the rarest forms of rupture, appearing only about once in four or five thousand cases of hernia examined. Berger, in 16,800 hernias of 10,000 patients examined in the

FIG. 83.—Lumbar hernia. (Enderlen and Gasser.)

Paris hospitals, reported only 2 instances of lumbar hernia. Few observers have seen more than one or two cases, a number of these being reported as cured by operation by Grasser, Brown, Wolff, Hein de Quervain, Macready, and others in Europe, also by Bull and Dowd in America.

When the latissimus dorsi is drawn backward the origin of the internal oblique and the border of the serratus posticus inferior are seen to be separated by a space covered with fascia. This space is bounded by the erector spinæ behind, by the external oblique in front, twelfth rib or the serratus above, by the internal oblique muscle below. Its floor is identical with the deep layer of the lumbar fascia—the fascia

lumbocostalis of Kocher. Pettit's triangle, especially its upper angle, is also believed to be a weak point in the lumbar region. Although this has been disputed by Braun, Dowd's successful operation, in a case of lumbar hernia, was performed at this point.

Lumbar hernia may be either congenital or acquired. In fetal life or in early infancy atrophy of the muscles of the loin may occur from nerve injury or from poliomyelitis, causing a yielding and displacement of their margins. In adults the occurrence of lumbar hernia has been known to follow traumatism by direct blows, by falls causing intra-abdominal pressure, by the strains of coughing and parturition, etc. The symptoms commonly observed at the time have been a sensation as of tearing felt at the moment of protrusion. There also have been reported cases in which the hernia has taken place in the scar tissue resulting from a cold abscess or a perinephritic abscess. The hernia may be double, as reported by Fedorows. In most cases a hernial sac has been found, but in 1889 Hutchinson reported an instance of traumatic lumbar hernia, the size of an orange, in which a sac was wholly lacking.

It is usually easy to determine the presence of a lumbar hernia, but not so easy to determine its exact point of exit or the location of the inner orifice. In 49 cases Jeannel found only 9 which had been examined by autopsy or by operation. In 4 cases only was the exact location determined, and, of these, 1 was found at Pettit's triangle and 3 at the superior trigonum lumbale.

Treatment.—The treatment of lumbar hernia may be like that of any ventral hernia, *viz.*, by means of trusses, provided the hernia is reducible. The operation is not difficult and, in good subjects, is reasonably safe. It consists (according to Dowd) in placing a double row of sutures in the margins of the muscles after the sac has been extirpated down to the orifice in the lumbar fascia. Kuester, in cases where the defect was very large, employed a special flap. He accomplished this by lifting up a large flap of skin, muscle, and periosteum from the crest of the ilium, rotating it, and then stitching it over the ring.

INTERNAL HERNIAS.

The term retroperitoneal or internal hernia is applied to those cases in which the viscera become entangled in their own internal recesses, without giving rise to any visible external tumor of the abdominal wall. There exit, along the course of the intestines themselves, several natural openings into which loops of bowel, especially of the small intestine, may slip and become strangulated. The chief locations of internal hernia are: (1) the foramen of Winslow; (2) the ligament of Treitz (duodeno-jejunal fossa); (3) under the colon (ileocecal, ileo-appendicular, etc.); (4) between the coils of the sigmoid flexure (intersigmoid).

1. **Hernia at the Foramen of Winslow.**—A few cases only—about twenty, according to Moynihan—have been put on record. It is

difficult for the small intestine to reach this foramen, which is located above the colon and duodenum and behind the common duct. When the mesentery is abnormally long or is continuous with the mesocolon, so that the latter is long and the colon not fixed to the posterior wall, or when the foramen of Winslow is abnormally large, conditions may favor the passage of the bowel through this orifice into the lesser peritoneal cavity.

Treatment.—The treatment of this condition is by open laparotomy, and there is presented to the surgeon a grave and almost insoluble problem as to how best to relieve the constriction. Our experience with gall-tract surgery has made us familiar with this orifice, as it is usually explored with the finger when an examination of the common duct is made. The anterior margin of the ring is formed by the gastrohepatic ligament, which carries the common duct, the portal vein, and the hepatic artery. Posteriorly we find the vena cava in close relation. Dividing the ring by cutting or tearing would seem to be impossible. Although Jeanbrau and Riche worked out, on a cadaver, a method of accomplishing this by mobilizing the structures in the ligament it has never been done on the living subject, and probably could not be done without causing death. It would be safer, as advised by Moynihan, to open the lesser peritoneum and drain the distended bowel to facilitate reduction, or to make a lateral anastomosis outside the obstruction and operate later for the hernia.

2. **Duodenal Hernia.**—Duodenal hernia, or paraduodenal hernia, appears at the point of exit of the jejunum from beneath the transverse colon. Since 1857, when Treitz first described this condition, numerous other cases have been reported.

Duodenal hernia was believed by Treitz always to be acquired, while Landzert asserts that it is always of congenital origin. Its sudden appearance in adult life points to a probable traumatic origin, as happens in a ventral hernia. Vautrin has reported 2 cases, in 1 of which he ascribed the trouble to an old scoliosis.

This orifice transmits the mesenteric vessels and nerves as well as the duodenum and hernia, but it may be divided with comparative safety on three sides. Hence there is less difficulty about relieving the strangulation and permitting reduction of the hernial mass.

3. **Retrocecal Hernia.**—Retrocecal varieties of retroperitoneal or internal hernia are of two forms—a superior, just above the ileocecal valve, and a lower or inferior, just below that junction or at the mesoappendix. The location of the sac is between the layers of the mesocolon and between the colon and lumbar muscles. The weak point, through which a hernia occasionally protruded, is just at the angle above or at that below the rectangular insertion of the ileum into the side of the cecum. From this location the hernia tends to follow the direction of the large bowel toward its hepatic fixture.

4. **Intersigmoid Hernia.**—The sigmoid has a long mesocolon, which, when lifted, is seen to be fan-shaped, with a central depression at the junction of its root with the posterior abdominal wall. This is sur-

rounded by the main trunk of the sigmoid artery. Hernias through this weak point pass into a tunnel-shaped channel that leads upward behind the peritoneum, in close relation with the superior hemorrhoidal and colica sinistra arteries.

Treatment.—The treatment of retrocecal and restrosigmoid hernias, if strangulated, meets the same operative difficulties as are encountered when the hernia is located at the foramen of Winslow. The vascular ring is almost complete and free division of the constricting bands is impossible. Extirpation of the sac is practically impossible in its inaccessible location. It may be left *in situ*, with the possibility of its forming a cyst. The ring itself may be closed by sutures if great care is taken to avoid encircling the artery.

FIG. 84.—Diaphragmatic hernia in child. (Enderlen and Gasser.)

Hernias of the Diaphragm.—Something over 500 cases of hernia of the diaphragm are now on record, and almost two-thirds of them were congenital. Thoma collected 433 cases, of which only 181 were acquired; the remainder (252) were congenital. In 248 cases Lacher found that a sac was reported only 24 times. These diaphragmatic hernias have also been classified as true hernias—*i. e.*, hernias having peritoneal sacs, while false hernias merely consist of openings in the diaphragm through which the viscera escaped. The former, the true hernias, constitute only one-tenth of the whole number reported.

Congenital absence or weakening of the central tendinous portion of the diaphragm allows the escape of intestine and stomach, especially

on the left side, into one or both pleural cavities. In acquired hernia the conditions are the same, the cause being a wound or rupture of the diaphragm. In some congenital cases the hernia has a true sac, especially at the esophageal or the parasternal opening. As might be expected from its location the stomach is most frequently found in the hernial sac. Rochard, in 330 cases, found that the different abdominal organs formed a part of the hernia in the following order of frequency, stomach, 187; colon, 17; intestine, 133; spleen, 78; liver, 60; duodenum, 48; cecum, 35; pancreas, 12; left kidney, 2; right kidney, 1.

In the case of a severe trauma, which causes a large tear through the diaphragm, the stomach lying against this opening, is the first organ to escape; it is forced directly into the pleural cavity by the difference of pressure in the two cavities. In a case operated upon by me in 1909 the colon escaped transpleurally into the open air underneath the liver, the chest being torn open above so as to expose the dome of the diaphragm. In spite of the fact that the lung also prolapsed and that half a dozen ribs were fractured, the patient made a good recovery. The wound in the diaphragm was sutured from above. Suppuration ensued in the chest and the patient had a recurrence of ventral hernia after leaving the hospital. In the preceding year I reported two other cases of diaphragmatic hernia which had come under my care in the Cook County Hospital. In one of these—a case of stab wound, recovery took place; in the other a traumatic rupture of the diaphragm was discovered at the autopsy. When the stomach enters the chest cavity, it is apt to drag after it consecutively the colon, the jejunum and small intestine, the spleen, and the omentum. In small wounds the omentum may be first to enter the opening. It contracts adhesions at this point and afterward acts as a wedge to dilate the orifice. Then, later, it drags first the colon and afterward the stomach by its lower border, thus inverting and twisting its pyloric end. Repetto, by experiments on dogs, proved that the tendency of the omentum to seek these openings was constant.

In the majority of cases there are noticed some symptoms of the hernia, either of abdominal or thoracic origin. Pains located in the epigastrium and left hypochondrium and radiating toward the shoulder, and digestive troubles are the symptoms usually noted. There may be a tympanitic resonance over the left chest, and there is usually dextrocardia.

In making a differential diagnosis it will be found helpful to employ insufflation with the stomach tube, and also to resort to the use of radiography after the patient has ingested bismuth.

Treatment.—The treatment of diaphragmatic hernia does not include the use of trusses or bandages and must be mainly operative. In many cases the associated injuries also call for operation. The important question is whether to make a transpleural or transperitoneal operation. Heidenhain advises the abdominal route for simple hernias and the transpleural for strangulated cases. Wahringer collected 26 cases, of which 22 were operated upon by the abdom-

inal and 4 by the pleural route. The fear of opening the pleura without the aid afforded by the pneumatic cabinet has deterred operators in general from opening the chest in these cases. In only 10 instances was the diagnosis made before operation. As no one operator has a large series of cases, it is important to determine, if possible, which method of procedure has the greater advantages. I believe that the transpleural route should be the one of choice in all cases requiring operation at all. The dangers of pneumothorax have been greatly overestimated and are largely illusory. The chest can be opened upon either side, as a rule, without much collapse of the lung. Temporary collapse, does not cause as much shock and dyspnea as was formerly believed. It is difficult or impossible to place stitches in the higher part of the diaphragm from the abdominal side, and practically impossible to detach adherent omentum or viscera from below. Cordier reports a case of failure, with fatal result, from an attempt to do this. Lejars advises the pleural route in reducible hernia because the abdominal route gives so many failures. Cranwell confirms this and strongly advocates the pleural route, citing cases of failure from operation below; many of these attempts having been made by good operators, like Abel, Martin, Schwartz, and Rochard. Like the French, the Italian surgeons were early advocates of the transpleural route and obtained brilliant results thereby. Postempski, Nine, and Sorrentino have practised and advocated operating through the chest wall. In 52 transpleural operations collected by Neugebauer the mortality was only 9.6 per cent. while in 10 laparotomies for the same affection the mortality was 50 per cent.

The patient should lie in the reversed Trendelenburg or Fowler position. The incision should extend from the eighth rib and should be curved with its convexity downward. The ends of the incision should be nearly vertical and the eighth and ninth ribs should be resected at these points. The pleura may then be opened and any adhesions broken up sufficiently to gain access to the cupola of the diaphragm. This lies very near the chest wall and can easily be repaired. If necessary, in order to reduce the contents, the hernial opening may be enlarged. The ring should then be closed with durable catgut, tendon, or other suture material. Cranwell used fine silk to unite the two layers of the diaphragm separately. The pleura should next be cleaned and dried locally by sponging with soft pads, and the external wound should be closed without drainage if the wound has been a clean one.

SURGERY OF THE PERITONEUM AND RETROPERITONEAL SPACE.

By WILLIAM D. HAGGARD, M.D., F.A.C.S.

The peritoneum is a serous membrane whose structure closely resembles that of the pleura. It lines the largest cavity of the body and covers an area of 17,182 square inches and is thus larger than the skin surface of the body. Reflected from the parieties it envelops more or less the abdominal viscera, giving them a smooth and glistening surface. The endothelial cells, when intact, are doubtless imperforate, except possibly in the region of the diaphragm where minute openings have been described. These pits represent small apertures directly communicating with the lymphatic system through the subpleural network of branching lymphatic trunks, which communicate with both the mediastinal and abdominal lymph glands and retroperitoneal spaces.

Formerly the peritoneal cavity was considered as an enormous lymph space and the existence of stomata was thought to bear out this view. McCallum has denied their existence, however, and embryology teaches that the entire lymphatic system owes its origin to an endothelial outgrowth from the subclavian vein, and has no connection whatsoever with the celom. Some observers have described small pit-like depressions scattered promiscuously over the diaphragmatic portion, into which foreign particles must fall before their exit through the stomata. It is yet uncertain and difficult to believe that a healthy peritoneum is pervious to the extent that actual spaces exist between its cells.

The fifth to twelfth dorsal nerves inclusive supply the peritoneum, as well as the anterior abdominal wall, and thus explains the characteristic muscular rigidity in injuries to the peritoneum and the marked superficial tenderness in inflammatory conditions. Only the parietal peritoneum is sensitive, the visceral portion is non-sensitive, except to traction.

Function and Defense Mechanism.—The dominant characteristic of the peritoneum is its great absorptive power. Absorption is carried on by the bloodvessels and lymphatics. The omental and diaphragmatic areas are the most active. In the region of the diaphragm solid particles, such as bacteria, lampblack, etc., are taken up by the lymphatics, probably never by the bloodvessels and are found deposited in the lymph nodes of the anterior mediastinum within six minutes after their reception within the peritoneal cavity. They are observed within the tissues of the spleen and liver fifteen minutes after injection. The

anterior mediastinal nodes receive the great bulk of extraneous solid substance absorbed by the peritoneum. Bacteria become entangled in a film of plastic lymph covering the endothelial surface. This enables the polynuclear cells and the macrophages to attack and destroy them.

The great danger in peritonitis is absorption. As Lannender has said: "It is the infection which kills and the peritonitis which saves." What then must be the relation between an inflamed peritoneum and absorption?

Glimm's exhaustive work shows that absorption is accelerated during peritonitis in the first fourteen hours.

The early increase lasting a few hours gives way to a decided decrease in the rate of absorption. This latter retardation is why peritonitis is a saving process.

The factors which aid absorption are: (*a*) The pump-like action of the diaphragm forcing the material caught within the spaces through to the pleural surface by its contraction; (*b*) peristalsis which aids in disseminating the infection over a wide range of surface and can be very largely controlled by treatment; (*c*) increased abdominal pressure by the involuntary and rigid contraction of the anterior abdominal wall in the endothelial cells; (*d*) the specific and vital power of absorption; (*e*) the peritoneal currents which waft the material to the most pervious localities, viz., the omental and diaphragmatic areas. Retardation of absorption is then promoted by Fowler's position; gravity combats this upward dissemination and favors localization in the dependent portions of the cavity. Dandy and Roundtree found that absorption was 15 per cent. less in the pelvis than in any other portion of the peritoneum. Fortunately self protective evolution has done away, to a large extent, with the stomata in the pelvic peritoneum, as it is so prone to infection from the Fallopian tubes and appendix. Moreover, there is an initial rush of leukocytes which clogs and chokes the lymphatics ("coffer damming of the lymphatics"). Venous engorgement necessarily hinders any active process of transportation. The various means of diminishing peristalsis tend toward localization. Shallow breathing is Nature's effort to restrict the harmful effect of the diaphragmatic excursions. Low intra-abdominal pressure or tension together with drying of the surface are factors. Low temperature militates against rapid absorption within the peritoneal cavity as it does elsewhere. Inhibited peristalsis with distention of intestine is a defense mechanism as is the fibrous exudate on the surface adhesions of adjacent coils of intestine shutting off invasion of other areas.

All forms of traumatism during operation, such as the diminution of endothelial cells or the severance of adhesions promotes rapid absorption. The peritoneum is also a secretory membrane. The viscera require a lubricating fluid. The great antibacterial properties caused Howell to designate it as a "perienteric trap," which immediately destroys certain bacteria permeating the gut wall or otherwise escaping from the alimentary canal teeming with microscopic life. Bacteriolysis is carried on within the peritoneum in a variety of ways. In typhoid,

for example, where the infection has reached the peritoneum the macrophages, the large endothelial cells, derived chiefly from the omental area, are the most active in phagocytosis, while the neutrophiles play a minor part.

The peritoneum is subject to developmental abnormalities, as are the other tissues of the body. The membrane may be absent in certain localities owing to an arrest in its development, or its growth may be superfluous causing folds and pockets which in later life might give rise to strangulated intestine and obstruction.

Various bands have been found and described around the colon. These normal folds facilitate localization of peritonitis. Eventration of the diaphragm has been mistaken for hernia into the thoracic cavity. It is, however, a congenital deformity of the diaphragm in which its left half is displaced upward, together with its associated abdominal viscera, especially the stomach, while the heart is pushed to the right.

The peritoneum is the only serous membrane which surrounds a septic field, the intestine, and in women the abdominal ostia of the Fallopian tubes affords an open gateway for ascending venereal and puerperal infections. For these reasons it has been given great defensive powers. The peritoneal fluid is rich in bactericidal properties. Within a short time after bacteria are injected, in moderate amounts, they are destroyed. Phagocytosis is very active in conjunction with bacteriolysis. The cells, macrophages and microphages of the peritoneal fluid are decreased during the first three hours following a peritonitis. Later they regain their numbers. Phagocytes are not only contained within the peritoneal fluid, but crawl along the surface, especially in the omental region, engulfing the bacteria. In animals the surface of the omentum is studded with "dull whitish opaque spots." These spots are made up of cells which subsequently become active in the destruction of bacteria. The process is continued in the lymph nodes, being most active in the nodes of the anterior mediastinum. The great organs of the body are called on to lend assistance, chief among these being the liver. The spleen and bone marrow also are of importance.

The peritoneum has the ability to throw out a plastic exudate which tends to limit the infection by adhesions. This initial and wholesale destruction of bacteria is described as an explosive bacteriolysis. After the primary reduction the bacteria steadily gain in numbers for a varying period and then begin to recede for a second and last time. Therefore, patients who can stand the primary onslaught have a good prognosis.

Tavel and Lanz originated the term chemical peritonitis. It must be admitted that this type is very rare. The bacteriological technic in determining the offending organism was faulty. Cultures were taken from the peritoneal fluid and those cases giving no growth or in whom the Staphylococcus albus was found were classified as chemical. It has since been demonstrated that the intraperitoneal fluid may be

sterile as far as our methods of determination are concerned, while the peritoneum itself may be alive with bacteria. This will necessarily narrow the field of chemical peritonitis, making it rarer than statistics have heretofore indicated. There are, however, certain well known conditions which give rise to mild peritonitides. Examples of this are the peritoneal inflammation, following the rupture of certain cysts, the escape of blood, uninfected bile and urine and the introduction of certain irritating but sterile chemicals. Dudgeon and Sargent claim that the peritonitis in cases of chemical irritation is due to the Staphylococcus albus. Murphy discredits this assertion and says that his experience with chemical irritants in the knee-joint does not give rise to the presence of Staphylococcus albus in that cavity. Idiopathic peritonitis is a myth in the sense that its cause cannot be discovered physically or bacteriologically.

ACUTE PERITONITIS.

Peritonitis is a very frequent, severe and often fatal disease. It occurs usually as a complication of many intra-abdominal lesions, as the result of external injuries and is terminal in many diseases.

Etiology.—By far the most frequent causative factor in peritonitis is perforation, either endogenous or exogenous. The endogenous perforation may occur at any portion of the alimentary canal, which is covered by peritoneum. The most frequent single site for leakage is the appendix. About 90 per cent. of the cases are caused by perforation here or at the pylorus. Other important sources of infection are the gall-bladder suppurations, with or without cholelithiasis; perforating, duodenal and gastric ulcer; sloughing gastric cancer; foreign bodies swallowed and perforating the intestine; tuberculous ulcerations and typhoid perforation.

Of the exogenous causes are gunshot wounds, penetrating or perforating; the stab wounds, or any other crushing or penetrating injury; subcutaneous rupture of the gut or other viscera, such as the urinary bladder which is sometimes fatal; rupture of a renal cyst; or abscess of any of the abdominal organs; pancreatitis, acute, suppurating or gangrenous; splenic infarcts. All of these may be causative. Next to the appendix, the genitalia in women are the most frequent paths of an ascending infection, resulting in peritonitis. The Fallopian tubes open directly through their ostia into the peritoneal cavity. Neighboring infections, such as suppurations of the retroperitoneal lymph glands, may by extension directly (continuity of tissue) at length reach the peritoneum. The lymphatics may offer an unobstructed route. Hematogenous peritonitis is rarely encountered, but does occur occasionally as a complication in the course of other diseases, as pneumonia, middle-ear suppurations and the tuberculous variety, following pulmonary consumption. Volvulus, intussusception and herniæ when strangulated are all etiological factors. When a branch of the mesenteric artery is occluded by a septic embolus, the results

are almost the same as the sloughing through of a peptic ulcer, or a perforation during the course of typhoid fever or intestinal tuberculosis.

Bacteriology.—Most inflammatory conditions of the peritoneum are caused by mixed infections. The most common single organism found is the Staphylococcus albus, which undoubtedly is a resident of the intestinal canal at the time of the onset and is therefore an early invader of the peritoneum. It is of exceedingly low vitality or virulence and is non-pathogenic. The invasion of the peritoneum by the Staphylococcus albus is rather a conservative process, since being non-pathogenic *per se*, it limits the more serious infections by the promotion of adhesions and by calling forth cells which do not "degenerate in its presence." The Bacillus coli communis is the most frequently found microörganism in peritonitis and is perhaps the deadliest with the exception of the streptococcus. It is a constant resident of the intestinal tract and when a perforation occurs nearly invariably the peritonitis is due to a pure or a mixed culture of the colon bacillus. The peritonitis resulting from typhoid perforation is due to this organism. Pus in such cases is characterized by an offensive and horribly fetid odor. According to Klenches the organism is most toxic in the ileum, decreasing in either direction and probably mildest in the jejunum. Connor states that bacterial activities attain their maximum in the cecum. Intestinal disorders are known to increase the virulence of the colon bacillus. Recent severe purgation lights up their activities. There are many strains of this organism but one type at least is present in nearly every case of perforative peritonitis. The virulence of this organism varies greatly being at times exceedingly deadly while at others the infection is very mild.

Streptococcus peritonitis is exceedingly fatal, yet some cases may survive. Fortunately, this type is not often encountered. A. O. J. Kelly recorded 1 case in 94 instances of perforative appendicitis. According to other observers it is not as rare as this. Conner and Cushing consider its connection with peritonitis to be underestimated, since it is difficult to grow the organism on the ordinary culture media. Its tendency is toward the production of septicemia. It kills generally within the first forty-eight hours. Those affected seem to die with or without an operation.

The streptococcus is prone to invade the lymph spaces and the subperitoneal tissue. Consequently from its incipiency the infection may be said to exist in the loose cellular tissue directly beneath the peritoneum, a tissue of great absorptive powers, a tissue of little vitality with no ability to limit the invasion which is rapidly and fatally progressive. Drainage of the peritoneum cannot possibly reach the real seat of the trouble, fortified as it is behind a membrane which shields it from surgical attack. Under such advantageous circumstances the organism does its murderous work with wonderful celerity and the patient dies during the first few hours, with apparently no attempt at resistance.

The pneumococcus type offers a better prognosis. It shows a dis-

tinct predilection for children and for children under fifteen years of age. It is said to be three times as common in children as in adults, and seven times more common in girls than boys. In 33 instances 27 were girls and 6 were boys (Quehart). The female generative organs are said to be responsible for the preponderance in girls. It is rarely seen in adults. Gastric perforations frequently give rise to this variety of peritonitis. The oral cavity and saliva nearly always contain the pneumococcus. Swallowing them would account for its presence in the stomach.

It may arise secondary to pneumonia and thus present a typical case of hematogenous peritonitis. This rarely occurs in adults, however. In 104 cases of pneumococcic infections in adults, there was no case of peritonitis. Mixed infections seldom occur. A ruptured appendix sometimes liberates the pneumococcus together with the colon bacillus. Of all the cases of pneumococcal peritonitis, one-third originate from distant foci; whereas, the other two-thirds come from the bowel (Fraser and Bowen). It sometimes follows middle-ear suppurations. It produces a greenish-yellow pus, odorless, more or less thick and rich in fibrin. Its typical onset is sudden and acute, coming, as it does, in the midst of health, without an assignable cause. In this regard, it differs from most other forms of peritonitis. The onset is accompanied by diarrhea, mental excitement and high fever. Pain and distention is not as great as in other forms. There is an acute and a chronic stage. After a few days the high fever vanishes. Appetite is better and the vomiting ceases. This lasts a few days and passes into the chronic stage. Recovery usually follows drainage.

Bacillus Pyocyaneus.—This organism may be extremely virulent or very mild. In some series its mortality is second only to the streptococcus. It is never associated with the colon bacillus and there seems to exist some antagonism between the two. The intestinal tract is probably never free from this bacillus. It is the chief producer of green or sometimes blue pus. However, green or blue pus is never formed within the peritoneal cavity, because air is essential to the formation of this pigment.

Gonococcal Peritonitis.—The long residence of this diplococcus in the mucous membrane of the genito-urinary tract has developed specific cultural characteristics and it often fails to grow upon a serous surface. When it is implanted upon the peritoneum it excites only a small and restricted area of inflammation and rapidly perishes. Furthermore, it fails to grow upon the genital mucosa of higher apes. Bovée found 55 cases of gonorrheal peritonitis in the literature. Murphy also saw 1 case in a male in the third week of an ordinary urethritis (specific). Gonorrheal peritonitis probably becomes of serious significance only in cases where a pus tube ruptures and suddenly throws a vast amount of contagion over a very wide surface. It is usually mild but can and does become very serious. The pulse-rate is said to increase more rapidly in this than in any other form of peritonitis. The infection is never diffuse, but is always practically limited to the pelvis by adhesions.

Mixed infections can occur and in these cases the peritonitis may be diffuse. It is self-limited and in the acute stage should be treated medically. Purulent cases in females should be drained vaginally. The pus is found to be odorless.

The Staphylococcus pyogenes aureus variety by many is considered rare. Dudgeon and Sargent give it a more prominent place. It is most apt to follow operations in which the technic has been faulty. It produces a yellow, golden or cream-colored pus. Anaërobes are seldom the cause of peritonitis.

Dudgeon and Sargent were able to prove one case which was due to the Bacillus aërogenes capsulatus. Other rare bacteria causing peritonitis are: Bacillus of tetanus; Bacillus mallei and the fungus of actinomycosis. Murphy gives the following list and in the order of their importance: Colon bacillus, streptococcus, pneumococcus, Bacillus pyocyaneous, Bacillus typhosus, the gonococcus and the Staphylococcus pyogenes aureus. Other germs mentioned are: Diplococcus intestinalis major and minor; the Bacillus pyogenes fetidus; Proteus vulgaris and Coccus conglomeratus.

Pathology.—Peritonitis is circumscribed or diffuse. If the bacterial invasion of the peritoneum is limited by adhesions it is called a circumscribed peritonitis. No matter how extensive the process may be, whether it be a small localized appendiceal abscess or the whole right half of the abdomen is converted into a pus pocket, the peritonitis is classed as circumscribed.

Where adhesions do not effectually localize the infection it is a diffuse peritonitis. It is described as spreading and general. General and diffuse have practically the same meaning. It is hard to conceive of a peritonitis which involves every square inch of the peritoneum and for this reason the term general peritonitis is misleading. It merely means that there are no limiting adhesions. This is all that can be determined at operation, plus the presence or absence of pus. At autopsy only is it possible to make a diagnosis of general peritonitis, so universal as to invade every nook and corner of the peritoneum. The term "general" is in its strictest sense a very improbable condition and if possible may be regarded as invariably fatal. Really, it is largely a clinical term to designate the very severe and perhaps fatal types of diffuse peritonitis.

Inflammations of the peritoneum are *septic* or *suppurative*, depending on the pathology present. To these terms may be added such adjectives as serous, fibrinous, hemorrhagic, serofibrinous, purulent, fibropurulent or seropurulent, which are descriptive of the exudate. The type of peritonitis with relatively slight changes in the peritoneum, but productive of a large amount of toxins, as Streptococcic peritonitis, are essentially septic. In severe septic cases, known as fulminating, death is probably due to bacteremia and sepsis, rather than peritonitis *per se*. The virulence is so pronounced or the resistance so impaired that the infection spreads like wildfire. After death the peritoneum is dry, there is no exudate, or no adhesions but the intestines are very red and tear easily.

When there is purulent exudation the process is classed as suppurative, and generally contains the Bacillus coli communis.

When the peritoneum is invaded by an organism it at once loses its luster, becomes a dusky, red color, thickened and edematous. Its surface is roughened and shows plaques of fibrin on the surface. As the process continues the membrane is dotted with petechial spots and hemorrhages may take place into the peritoneal cavity, due to erosion of a vessel. A serous exudate is regularly poured out over the surface, which is not only bacteriolytic, but is rich in phagocytes. This exudate is more or less impregnated with fibrin and in favorable cases the fibrin soon becomes abundant enough to form temporary adhesions. The exudate generally becomes purulent. The endothelial cells are sometimes destroyed by the virulence of infection, thus permitting raw surfaces to touch and rub each other, which probably accounts for some of the pain. Later these raw areas form permanent adhesions. Sometimes a membrane forms over the surface of the peritoneum, a fibrinous membrane which later in the disease becomes necrotic and is thrown off. This leaves the peritoneum raw with capillary blood and lymph space open permitting of the fresh absorption and death usually results in three or four hours after its occurrence. In the early stages of peritonitis the loose connective tissue lying just beneath the peritoneum becomes thickened, hard and indurated. Myriads of white cells are mobilized, choking the atria of absorption and systemic invasion, while the exudate poured out in the front and rear of the invading microörganisms directly combats the organisms and forms adhesions on the peritoneal side. The gluing of intestinal coils together making a barrier around the advancing or increasing infective agent is Nature's chief defense. Next the ubiquity and efficiency of the omentum in surrounding and combating a local infectious lesion is the constant and dominant peritoneal defensive action. These adhesions are temporary and are absorbed usually within six weeks. Real fibrous adhesions are permanent and may give vicious symptoms.

Puerperal peritonitis is really an example of retroperitoneal cellulitis. The peritoneum is involved also but like all streptococcic infections the brunt of the fight is in the rear of that membrane. In cases of streptococcic infection the peritoneum shows very little reaction. The membrane may be dry, without its luster and dusky red with minute petechial spots. Sometimes there may be a small amount of serous exudate. Nature is overpowered from the onset and death occurs before any reactionary changes can take place in a majority of the cases.

In pneumococcal peritonitis there is an abundant fibrinous exudate which mats together coils of intestine. For this reason probably the disease has a strong tendency to localize early and to localize in the pelvis or hypogastrium. In a few cases these localized collections of pus have ruptured through the umbilicus and through the vagina. In the latter stage of the disease the child becomes emaciated, presents a fluctuant tumor in the hypogastrium, has marked remissions in temperature, profuse sweats and grows steadily worse. At necropsy this

condition is often found associated with empyema, pneumonia, pericarditis, lesions of the alimentary canal and otitis media.

In the ordinary suppurative type of peritonitis the loss of luster and dusky red color of the membrane, due to a dilatation of its vessels, is rapidly converted into a dull whitish color, as the leukocyte infiltration increases. The serofibrinous exudate quickly becomes purulent. The process may or may not be walled off. On incising the belly the peritoneal fat is found edematous, the peritoneum is thick and indurated and presents a cloudy appearance. The intestines are distended with fluid and gas, which is probably due to toxic paralysis of the sympathetic nerves. Lannender found changes in the nerves of Auerbach's plexus in such cases. This paretic condition favors absorption. Gangrene has been known to result and unless adynamic paresis can be relieved it soon becomes a most serious condition. Within the first twenty-four or thirty-six hours the leukocytes have had sufficient time to infiltrate the peritoneal and retroperitoneal tissues and the fibrinous exudate has begun to limit the field of invasion by temporary adhesions. Therefore, in patients surviving the first thirty-six hours the prognosis is more favorable. The pathology and the outcome depend upon (1) the character and location of the original lesion; (2) the amount of virulence of the infection; (3) the rapidity of its introduction; (4) the resistance of the individual.

Symptoms.—In the great majority of cases peritonitis is the result of perforation, either of the appendix or near the pylorus, and the preceding history, as well as the primary symptoms with which the patient is taken is of importance. Usually the patient is suddenly seized with excruciating, cramp-like pain in the abdomen, which may at first be localized to the area of perforation, but later becomes general. Often the pain is epigastric, irrespective of the location of the lesion. If localization occurs the pain settles there. In severely septic cases the pain may be slight or absent. If perforation allows some inundation there is a sudden drop of temperature, the skin is cold and clammy and drops of sweat stand out on the forehead. There may be a slight chill and the patient may go into collapse. There is marked tenderness and rigidity at the site of perforation which spreads as the inflammation spreads and soon becomes general. The hand of the patient hovers around the examiner's hand to prevent pressure on the very tender abdomen. The weight of the bed clothes is sometimes unbearable. The slightest jar increases the pain and walking in the room is often complained of by the patient. At first the pulse is hard, small and rapid. Later it becomes weak, thready and compressible. A rising pulse with falling temperature is an indication that the peritonitis is spreading. Although there may be an initial drop in the temperature it soon rises and may reach 105°. While temperature is the rule, if absent it counts little; if it is subnormal and associated with cyanosis, the outlook is very bad. Chills are rare, but are occasionally initial and often denote a gangrenous process. They rather frequently inaugurate a puerperal peritonitis. Nausea and vomiting are rarely absent. Vomiting causes

pain, as does coughing, pressure and motion. As the peritonitis becomes more diffuse the patient assumes a characteristic position. He lies immobile with thighs flexed and if possible with shoulders elevated. There is increasing abdominal tenderness and rigidity. Breathing is shallow, quick and costal. The abdomen becomes distended, tense and tympanitic. Abdominal respiration gives way to the short, shallow, quick, thoracic type, and the meteoric abdomen is motionless. Hiccough is somewhat frequent, is very annoying, well-nigh uncontrollable and of bad omen. Vomiting soon returns. At first the vomitus is only the normal content of the stomach, it later becomes a bitter bile-stained fluid and lastly it is brown or black and has a decided fecal odor. In peritonitis the "black vomit" is as portentious as in yellow fever. In the beginning the vomiting is accompanied by nausea and is intermittent, later it is almost continuous and the patient brings up a gulp or two every few minutes and without apparent effort. Possibly some of the toxic material is excreted into the intestinal tract and the incessant vomiting of peritonitis may be Nature's method of elimination. Frequent lavage is imperative. Early diarrhea is sometimes present, which may be an effort at eliminating the toxins. Morphin will partially mitigate and mask nearly all of the symptoms and physical signs. It should be withheld if possible until the diagnosis is made. The eyes are sunken and the nose is pinched. The French call it *abatement* of countenance. It is the Hippocratic facies.

As the disease progresses, the tongue becomes coated and dry. Sordes collect on the teeth and the breath is foul. The face is drawn and the expression anxious.

The victims of peritonitis usually remain conscious and keenly alert until near the end when delirium or stupor may supervene. The urine is dark, scanty and full of albumin, sometimes casts are present, due to both the high fever and the toxemia. The patient is unable to expel flatus or feces, owing to an adynamic ileus. Obstipation may be so absolute as to resemble a mechanical ileum. In the last stages the patient becomes cold, clammy and cyanotic. Pulse is weak, rapid and irregular. Death is the result of the effect of the toxemia on the heart and vasomotor center.

In the early stages localization may precede perforation and allow early operation. Rigidity is the most valuable and constant finding. It is an index to the severity. In extreme cases and in perforations in the upper abdomen, it may be board-like. Leukocytosis is nearly always present. It commonly goes as high as 15,000 and often higher. If it increases it is significant. If it is absent the prognosis is unfavorable.

In the circumscribed variety a tumor or mass will be appreciable sometimes as early as the second or third day. In mild cases the patient may be up after a short initial pain and a mass containing pus not be detected until the seventh to twelfth day. Abscesses usually become larger, if not evacuated, and may rupture secondarily into the free peritoneum with symptoms of shock. The abscess sometimes escapes through

an abdominal fistula. Abscesses do not empty through the intestinal lumen as often as has been supposed.

Diagnosis.—The typical course of a perforative peritonitis is almost unmistakable, but oftentimes the condition arises during another acute illness, which may be of such serious import as to mask even the signs of peritonitis. In typhoid fever peritonitis is apt to occur in the third week. One-third of the deaths from typhoid result from perforation. For this reason the abdomen should always be under surveillance. Pain is said to be less in cases of infection within the central area than on the visceral surface.

In every mild case much can be learned from the previous history. A gastric or duodenal ulcer always gives antecedent symptoms, many of them warn their victims for months and years. A history of recurrent appendicitis may precede a sudden, diffuse peritonitis. The pain, nausea and tenderness are important and point to peritoneal involvement. Murphy has called attention to the order of the appearance of symptoms: (1) Pain; (2) nausea or vomiting; (3) tenderness and rigidity and (4) temperature. He also taught that intra-abdominal exudate is more readily elicited by piano player's finger percussion. Once the diagnosis of intraperitoneal abscess is made, operation should be immediately performed, since the slightest motion, a sudden turn in bed may cause its rupture and a fatal issue.

Those cases of hematogenous peritonitis coming apparently out of a clear sky, may be anteceded by chronically infected tonsils, or other trivial lesion which only the closest scrutiny will detect. A high leukocyte count is nearly constant. The differential count is of prognostic importance. The total count is said to be more often above 15,000 than below it in cases of suppurative peritonitis. A total count of 25,000 would mean an extremely severe infection, or a very virulent strain of bacteria. If the polynuclear neutrophiles, which are the real phagocytes, show a relative proportion of over 90 per cent., then the prognosis is good. The converse presents a grave outlook. The principle of surgical treatment is to operate and remove the source of infection as early in the disease as possible.

Differential Diagnosis.—An abdominal colic is always potentially serious and frequently denotes a beginning peritonitis. Colics due to intestinal fermentation, to gastro-enteritis, to lead, to kidney-stones and gall-stones are usually unattended with temperature, leukocytosis, marked tenderness, rigidity and distention. They have individual characteristics that designate them. More mistakes are made by interpreting lesions eventuating in peritonitis as "indigestion," "colic," etc., than *vice versa*.

Pneumonia, especially in children, is often inaugurated by abdominal pain and if there is diaphragmatic pleurisy the abdomen is tender and rigid, and closely simulates the acute peritonitic abdomen. A careful physical examination of the chest will often discover early signs sufficiently suggestive to prevent operation.

Mechanical ileus can be differentiated from intestinal paresis of

peritonitis by a lack of leukocytosis and by the presence of "stormy peristalsis." Temperature is almost invariably absent in the beginning of obstruction and is almost invariably present in peritonitis. Inflammatory ileus is much more frequent than mechanical. In the beginning they are easily differentiated. The inflammatory patient has been sick for some days before the obstipation becomes conspicuous. It is often accentuated by ill-advised efforts at purgation, which being futile on account of Nature's masterly inactivity, gives rise to the erroneous conception of mechanical obstruction.

Real obstruction is inaugurated by severe, sudden, pain coming on in a previously well person. The vomiting and obstipation are afebrile. Later the vomitus is stercoraceous. Peristalsis is visible and the intestines arch up in cats'-back patterns. Peritonitis has the silent abdomen. Other disorders such as thrombosis of a mesenteric vessel, pancreatitis, tubal pregnancy, with rupture, require thorough discrimination.

In acute peritonitis in women close attention should be paid to the pelvic history and vaginal examination should be made. Tenderness, if skilfully elicited is valuable. In localized peritonitis about the Fallopian tubes alternate lateral pressure on the cervix will elicit it, as well as direct palpation of the vaginal vault and the detection of a mass. Salpingitis sometimes has a sudden, acute onset and mimics appendicitis perfectly, and operation discloses a little pus in the tube which can be squeezed out.

Treatment.—The treatment of peritonitis is essentially the removal or repair of the primary focus, if possible. Operation should be performed as soon as the disease has been recognized. All cases of peritonitis from perforation of stomach, duodenum, or other hollow viscera by gunshot or stab wounds, imperatively require operation within the first eight hours, if possible. The patient should be moved to the operating table in the Fowler position. If vomiting is severe and due to obstruction, the stomach should be emptied by lavage before operation. An incision is made at the site of perforation, if this has been indicated in the history and findings. The area of lymph flakes will indicate the location of lesion. If the cause of peritonitis is unknown or undetermined look for the appendix first. When obstruction is the cause of the peritonitis and if the cecum is distended, the obstruction must be distal. If the sigmoid too is distended and a rectal examination is negative, the peritonitis is not due to obstruction and the distention is paralytic. When the obstruction is in the small intestine, following the distal collapsed loops will carry one to the point of obstruction which is at the junction with the proximal distended loop.

In perforative peritonitis two things should be done: (1) The perforation, wherever it is, should be closed, and (2) adequate drainage should be established, both near the site of perforation and in the cul-de-sac, if necessary, and in any other pus pockets. The perforation should always be closed. Relying on drainage alone is incomplete and ineffectual. Laspeyres operated on 18 cases and depended on

drainage alone. Of these 17 died immediately and 1 four months later. In a series of 15 operations, where the perforations were closed 5 recovered. Gauze wicks rolled in gutta-percha tissue like a cigarette are the best means of drainage. Split rubber tubes are also employed. It is not necessary to drain the clear, odorless serum, that is really defensive, but drain the offensive pus. The good results from non-drainage come from early operation and avoidance of conditions demanding drainage. It is unwise to do too much. Avoid evisceration as much as possible. In every case of peritonitis, whether localized or not, one should never fail to explore the pelvis with a long glass catheter as a capillary tube, a small sponge on holder, or a suprapubic incision if the original incision or focus has been in the upper abdomen. Often large quantities of more or less infected fluid will well up.

Irrigation of the peritoneum has been largely abandoned except where there has been a recent and considerable escape of foreign material. Moisture hastens absorption. Aspiration of infected fluids by the Blake tube and a suction apparatus is very useful and effectual. Where there is great distention of the intestine, empyting one or more loops by a glass tube introduced through a small opening, after the method of Moynihan, is extremely important. Washing and trauma are harmful and time counts here as nowhere else.

Following operation the Fowler position should be maintained just as before. Nothing should be given by mouth, not even water for a while, especially if vomiting is a prominent symptom. Ochsner taught us that absolute quietude of the patient, and inhibition of peristalsis was the desideratum. Nearly everybody learned the starvation feature but disregarded the underlying principles, and still persisted in the mischevious and often murderous efforts at purgation. Ochsner's plan was published in 1900, and yet it is a frequent and sad experience to see widely diffused peritonitis as the result of purgation, plus delay. The latter is bad enough, but the lesser evil. Ochsner says he has rarely seen a death from peritonitis of appendiceal origin when no food or purgatives were given from the start. Munro says "the underlying reason for using the Ochsner treatment is that peristalsis spreads peritoneal infection." If all foods and cathartics are withdrawn, and if the stomach is emptied of nauseating regurgitated contents, the peristalsis is reduced to a minimum and meteorism is diminished. By this induced rest the peritoneum can dispose of much infection, and an opportunity is allowed for a localization and imprisonment of the infecting organ. In other words the peritoneum is splinted. Once allow a barrier to encompass the focus, in a majority of cases an inflamed appendix or gall-bladder, and a progressive peritoneal infection is stopped. As soon as isolation is well secured, operation can be done with comparative safety. To carry out this treatment, all food by the mouth should be absolutely prohibited. No laxatives nor cathartics should be given. The stomach should be washed out thoroughly one or more times, until that organ is completely freed of the backflow from the upper intestines. Rectal feeding, in amounts not exceeding

4 ounces, and not oftener than every four hours will furnish sufficient alimentation. Ochsner maintains that if this is instituted early the most violent and dangerous forms of acute gangrenous or perforative appendicitis become comparatively mild or harmless. It is especially applicable to cases of beginning diffuse peritonitis. There is no doubt but that the basic principle of this treatment is a long step in advance in dealing with peritonitis in general. Its specific application requires judgment, and it is best used in the hands of surgeons experienced in operating, or in the hands of the general practitioner remote from surgical centers. It is adapted, for the most part, to inflammation of the appendix and gall-bladder; its employment in peritonitis secondary to strangulation, ulcers, etc., implies bad judgment.

Deaver has lately shown the devastating effects of purgation. He asserts that purgation is more deadly than the scalpel, and analyzes 79 cases with a history of purgation and found in all save 2, at the time of operation for appendicitis, that the organ was either perforated, gangrenous, or surrounded by an abscess. Of seven deaths in this series, five patients had been purged, and of those who had been drastically purged, nearly all showed a very severe type of disease. The purge in peritonitis is the submarine to Nature's allies.

The value of gastric lavage, before and after operation in peritonitis, is incontrovertible. The removal of quantities of decomposed food, or even bile with the mysterious poison which seems to emanate from the duodenum, is very essential. In its employment, however, one should not neglect to cocainize the pharynx. This gastric lavage, if attended by great resistance, straining and vomiting, while intended to be beneficial, is about as harmful as food or purgation in causing movements of viscera and dissemination of the infecting material.

All surgeons are agreed that in the advanced cases of peritonitis, when the patient shows a clammy, blue skin, extremely rapid pulse, low or subnormal temperature, with great distention, a motionless abdomen, low white cell count or leukopenia, that operation is practically useless. Patients in cases of less severity may recover with gentle and skilful interference. It is not to be denied, however, that interference at an inopportune time sometimes brings disaster, when the utilization of the Ochsner principles, plus deep morphinization, might have availed. It is a common experience with fifth- and sixth-day cases, before the complete walling off has taken place, that when infection is at its zenith and the resistance of the patient has not yet overcome it, particularly when the condition is very grave, operation in all probability would prove fatal, and yet with these rational measures improvement is manifest and in a few days the abscess becomes encapsulated and can be cured by simple incision and drainage.

In pelvic, postabortal and gonococcal peritonitis, operation should rarely, if ever, be instituted in the acute stages. The principles of Ochsner, and the Fowler position are especially applicable here. If a localized abscess forms in Douglas's pouch, it can be easily incised and drained from the tenth to the fourteenth day.

Acute puerperal peritonitis is in all probability streptococcic and usually fatal, yet the peritoneum can be drained very simply by incising the posterior vaginal fornix under novocain, in Sim's position.

Proctoclysis flushes the peritoneum from within out.

Murphy's addition to the principles of early operation, minimum interference, compatible with rapid and efficient work, was the instillation of large quantities of salt solution through the rectum. It restores body fluids, dilutes toxins in the blood current, causes a great transudation of serum into the peritoneum, irrigates it with its bacterins and helps manufacture lymph for trench warfare around the focus of infection. Its technic needs to be very actively gauged to insure results. As a maximum 18 pints have been administered in twenty-four hours. When it is not retained, Murphy says it is the fault of the method of administration.

The stomach-tube should be employed as frequently as necessary to keep the stomach empty. Fluid may have to be given subcutaneously in large quantities, 2000 c.c. in twenty-four hours. Hypodermoclysis should be started during the operation in bad cases and repeated every four to eight hours. If glass tubes are used for drainage, they should be gently rotated every few hours to prevent plugging of the openings.

In colon peritonitis vaccine is said to raise the patient's index about five times, but is not generally depended on. The antistreptococcic serum theoretically should be of value in streptococcic cases, but practically has been disappointing.

The value of morphin in peritonitis is that it relieves the pain, it quiets the intestines, it is a mild stimulant to the heart and above all it gives the patient a much needed rest and a chance for his life. Alonzo Clark especially emphasized it.

Crile in advancing the fascinating kinetic theory of peritonitis, has in effect drawn our attention to the very great value of deep morphinization to insulate the patient from the fatal dissipation of his energy in fighting his disease.

He has shown that the lethal results of peritonitis are due to the great exhaustion with its destructive action on the great organs, that is, the brain, the liver and the adrenals. This results from the enforced transformation of potential into kinetic energy used in defense. All of the local and general symptoms are Nature's combative response to the infection. The pain compels the patient to assume a "box-like rigidity." The anorexia, vomiting and obstipation prevent ingestion and the dissemination of infection by peristalsis. The temperature burns up the protein compounds of infection. The distention of paresis, the exudation of lymph, the gluing of viscera together are efforts at walling off infectious areas or products. All these symptoms, therefore, are really wonderful, automatic and often successful efforts at protection and self-cure, but they require great expenditures of kinetic energy. Can we protect the individual from this loss of energy while the "offensive movement" of phagocytosis continues? If the patient were

asleep and oblivious to the conflict that was costing him nothing in the output of energy, he would be thus aided and abetted while his forces overcame the infection. This can be greatly promoted in the severest cases that cannot be handled in the usual way by keeping the individual deeply narcotized with morphin after operation. The respirations should be held down to 12 or 14 per minute.

The restoration of energy can be kept up by the introduction of large quantities of fluid, by the seeping method of Murphy. Proctoclysis flushes the peritoneum from within out. Plain water as advocated by Trout can be used or it can be impregnated with salt, glucose for nourishment, or sodium bicarbonate to antidote acidosis. By the anoci method Crile has been able to reduce his deaths to only 2 in 391 cases of acute appendicitis, with and without peritonitis, with the addition of narcotization in the very severe cases.

One of the great problems which is apt to arise in the later stages is adynamic ileus. Ordinarily it yields to high enemata, one quart of water and one-half ounce of alum. It may be so pronounced as to resemble mechanical ileus and the question of operation arises. In postoperative mechanical ileus, of course, operation should not be postponed. Where peritonitis infection seems to be the chief trouble and the existence of obstruction being undetermined, enterostomy in the desperate cases, under local anesthesia, is indicated and may be successful. It certainly will be if the symptoms are largely due to obstruction.

In peritonitis, while death may ensue at any time, there are two periods in which if the case be a fatal one, the patient is most apt to die. If they survive the first few days, as has been indicated, they are likely to live until the tenth day. Dudgeon and Sargent state that their cases died within the first few days, or lived until the tenth or twelfth day.

After operation the surgeon must be alert for such complications as acute dilatation of the stomach, intestinal obstruction, toxic nephritis, septic pleurisy, embolic abscess of the lungs, liver or heart, subphrenic abscess, and other secondary abscesses, fecal fistulæ, etc.

The essential treatment, with or without operation, is an absolute prohibition of anything whatsoever by mouth, with immediate preparation for operative relief when possible. When for any reason this cannot be done, the continuance of this principle with the addition of deep morphinization are the most dependable methods. After operation drainage by the glass tube suprapubically and the employment of the upright posture and proctoclysis is the best plan of procedure.

TUBERCULOUS PERITONITIS.

Tuberculous peritonitis or the chronic form of peritonitis is due to the Bacillus tuberculosis. Cummins states that it occurs in 3 per cent. of all autopsies. It is nearly always secondary to tuberculosis elsewhere. It is rarely seen in infants under one year of age. It is not uncommon in

children under five, is most prevalent during young adult life, and is rare after forty years of age. It is most common in women from twenty to thirty and sometimes comes on shortly after childbirth. Osler reported 131 cases in females to 60 in the males. In children the infection usually comes from the intestinal tract. Milk from tuberculous cows is probably the mode of introduction. In rural communities where milk is the chief article of diet in the young, abdominal tuberculosis is prevalent. In cities where milk is rare, abdominal infection is rare compared to the pulmonary form. Gynecologists have long held the Fallopian tubes responsible for nearly 40 per cent. of the cases in women. Doubtless the pulmonary form causing a secondary involvement of the peritoneum, through the blood stream is the most common sequence. The appendix is not an infrequent focus especially in males. Other neighboring foci of infection, such as tuberculous mesenteric lymph nodes, or intestinal ulceration are frequent causes.

Murphy says that tubal tuberculosis is by far the most frequent type and that it is usually bilateral. But while the tubes are infected the remainder of the genital tract is uninvolved. Tuberculosis of the vulva is one of the rarest forms of this infection. Veit in 7000 necropsies found 450 cases of tuberculous women with only 18 instances of genital tuberculosis. Baumgarten found that after infection of the genital tract in rabbits the tubercle bacilli sought a lower level for extension and not a higher one. Minute foreign and inert material when injected into the peritoneal cavity are found within the tubes at a later date. Tubercle bacilli were observed in the Fallopian tubes of a woman who died of pulmonary and intestinal tuberculosis. It is evident that the Fallopian tubes are more often secondarily affected from the peritoneum than *vice versa*. Some observers find peritoneal tuberculosis more often in men than in women at autopsy, but operative records show a preponderance in the female. Many abnormal conditions existing within the abdomen seemingly predispose to tuberculous involvement. It may exist exclusively in a hernial sac. Patients suffering from cirrhosis of the liver not infrequently develop this disease. Osler speaks of the frequency with which ovarian tumors become involved. In many instances the disease is localized. It is not often primary but extends from tuberculous involvement of the pleura, pericardium, seminal vesicles and prostate. The bacilli may in some instances seep through the intestinal wall leaving no visible atria. In such cases the disease must be classed as primary. Or it may be the final issue of a general miliary process. The onset in two-thirds of the cases is said to be slow and insidious. A few are sudden, showing acute manifestations. In some instances it has been mistaken for typhoid fever. In other patients the process is latent and is met with during operations for other causes, such as obstruction, hydrocele, etc.

A classical association of symptoms in women is a persistent rise of afternoon temperature, an appreciable ascites and some enlargement of

both tubes on vaginal examination. Leukopenia is significant. The cases may also have slight colics, nausea, diarrhea alternating with constipation. The effusion may be circumscribed by adhesions and some cases thereby undergo resolution.

Pathology.—Tuberculous peritonitis has been variously classified as to pathological findings. The ascitic form is the most frequent and the most favorable for operative cure. The free fluid is the chief characteristic, and the intestinal and parietal serosa is studded with myriads of minute and shot-sized white tubercles. The adhesive variety represents Nature's way of combating the infection but does not admit of easy removal of the chief focus, on account of the danger of intestinal injury with resulting intractable fistula. Other forms, as fibrous and suppurative, are encountered. The fibrous type has the best prognosis, the ulcerative the worst. In mixed infections with abscesses few recover. At times the mucous surface of the gut is involved, as well as the serous surface. Pain here may be due to peristalsis, one raw surface rubbing on another, adhesions or to inflammation of the lymph nodes around the aorta.

Symptoms.—Pain is a conspicuous symptom at times though it may lessen and almost disappear. The symptomatology may be exceedingly complex. Nearly always there is an elevation of temperature, which is highest in the afternoons. In the acute cases this may be as high as 105°. Associated with this remittent fever there is gradual loss of weight and nocturnal sweats. Ascites nearly always develops. The dropsical collection may be considerable and the abdomen appears to be the size of an advanced gestation, but is peculiarly tense, white and shiny. Visible veins may course under the skin and the umbilicus often protrudes and is taut with fluid. The tuberculin test should be made in doubtful cases. The simultaneous development of a pleural effusion with ascites is almost pathognomonic. The skin in many cases comes to resemble the complexion in Addison's disease. Diarrhea is often present but constipation may develop or the two have been known to alternate. Pain, soreness and tenderness are more or less constant. Rectal examination usually shows enlarged lymph nodes. The disease is nearly always associated with some type of abdominal tumor. This tumor may be lymphatic, due to matting together of large coils of intestine or due to a curled up omentum lying athwart the upper abdomen and to the right. Tympany anteriorally with flatness or dulness in the flank may be encountered. The fluid may become encysted and present a fluctuant tumor. Examination of the lungs, as well as of the entire body is very important. An acute onset gives a bad prognosis. The ascitic form may be mistaken for dropsy, for cirrhosis, for an ovarian cyst, multilocular or papillomatous, or for peritoneal carcinomatosis with free fluid and nodular masses.

Treatment.—If improvement does not follow a carefully conducted antituberculous regimen, operation is indicated and that early. The reason the surgical cases have not greatly exceeded the results of medical management is doubtless due, as pointed out by Ochsner, to the

fact that only the more advanced and severe ones are submitted to operation. In the ascitic cases, especially, surgery is indicated. The abdomen should be opened by a moderately large incision, the primary focus, either the tubes or appendix sought for and if possible removed. The ascitic fluid is allowed to escape. Exposure to the air was formerly thought to be curative, but really it is the mechanical irritation which stimulates leukocytosis. It certainly causes an active hyperemia which brings more and better blood, with its opsonins, to the infected areas. Hofmann advises painting the omentum and intestines with 10 per cent. iodin, which is wiped off, to increase the hyperemia. Formerly operations were performed in the sunlight where the rays of the sun could penetrate directly into the peritoneal cavity. The abdominal wall should invariably be closed without drainage. The older method of sponging out the peritoneal cavity with a solution of bichloride, 1 to 1000, before closing is worthless. Pure oxygen has been admitted into the cavity with suture of the wound to prevent its escape. Convalescence should be assisted by good roborant treatment. Fresh air, sunshine and a plentiful and nutritious diet, with tonics are valuable. Sunshine is so important that an exact method of its applications has been developed by Rollier, which is very efficacious. Many patients spend several months in the western States following an operation. When surgical effort is augmented by the latest and best hygienic treatment upward of 50 per cent. of cures result. These cures are permanent, every trace of tuberculous taint being eliminated. Three years should elapse in order to consider the cure permanent. The percentage runs as high as 75 per cent. in some instances. A purely medical régime claims 50 per cent. of cures. Murphy advises tuberculin and *x*-ray treatment, without operation, but Mayo in common with most surgeons employs the removal of the focus, if possible, supplemented by hygienic management.

FOREIGN BODIES IN PERITONEUM.

Various kinds of foreign substances may find their way into the peritoneal cavity. Quite often, relatively speaking, this accident follows surgery after the most careful and painstaking technic has been observed. Different clinics have devised their own methods of preventing foreign bodies becoming concealed in the abdominal cavity during operations which has done much toward lessening the occurrence. But in the stress and urge of an operation, the unexpected complications, the concealment of a sponge or a forcep, by the coils of intestine and the fallibility of human effort, always makes this accident probable and it will occasionally occur in spite of the most elaborate precautions. Any uniform and simple system vigorously maintained with unvarying watchfulness will minimize this mortifying accident.

Foreign bodies may become lodged within the abdomen after being swallowed, by perforating the intestine. Or the peritoneum may be the receptacle for a bullet, which has penetrated the abdominal wall.

Von Berger's experiments prove that by the seventh day a sponge or other foreign body, if aseptic is surrounded by a layer of granulation tissue, which completely encapsulates it. The results of a foreign body within the abdominal cavity depend on whether it is sterile or septic. Neugebauer classifies them according to their results as follows: (*a*) septic or aseptic; (*b*) chemical substances as iodin; (*c*) thermic and (*d*) purely mechanical. As most articles left within the cavity of the peritoneum at operation are sterile their mechanical effects are of next importance and walled off may remain symptomless for years, always subjected to the destructive attacks of the white cells. Depending then on its composition the foreign body may or may not be entirely or partially removed. In one reported case a sponge became disintegrated after being in the peritoneal cavity for one and one-half years and was discharged piece by piece. A foreign body is always more or less an irritant and in this way leads to its expulsion or to suppuration or both. Its exit is at the point of least resistance which in many instances is an operative wound. Following a laparotomy the incision may heal primarily and later break down with a purulent discharge and the protrusion of a gauze sponge. It may penetrate the intestinal wall or, as happened in one case, the urinary bladder. Penetration is usually a slow process. Irritation leads to ulceration and perforation. Pressure atrophy plays a more or less prominent part, depending on the composition, size and weight of object. Adhesions have ample time to develop and wall off both the foreign body and the intestinal wall at the point of penetration, so that when the bowel is opened no infection or peritonitis results. The foreign body may be passed by the rectum and the patient recover. In other cases the cavity or pocket left by the discharged article may not collapse and heal. A fecal fistula may result and in such instances surgical intervention is necessary. Sometimes a large abscess may form externally and even rupture with a profuse discharge of pus and the foreign body. If the foreign body is entirely expelled perfect recovery takes place. If not, a discharging sinus will persist until the object has been surgically removed. An old discharging postoperative sinus is very suggestive of a foreign body.

Penetration is not always a chronic process but may be brought on suddenly by a blow or jerk, etc. In 1 reported case two hemostats left within the peritoneal cavity at operation caused death some time later by penetrating the left external iliac artery. Though foreign bodies may remain quiescent for years within the peritoneum, in the majority of cases serious trouble ensues. It is estimated that 50 per cent. lose their lives. In a few instances Nature has been able to remove the foreign substance, either by absorption or extrusion. The course has been properly said to depend on various factors, such as sepsis, size, composition, weight, character, location within the peritoneum, individual tolerance of the peritoneum, and the behavior of the patient.

Diagnosis.—There is usually pain of varying intensity situated and localized in the area occupied by the foreign object. The pain is more

or less constant. The patient does not recover perfect health following operation, but runs a low grade septic temperature, with loss of appetite and slight chilly sensations at times. The picture may be that of a mild ileus. Sometimes there is vomiting due to peritoneal irritation. A tumor may be present which is movable and from its general contour an idea as to its nature may be obtained. Rectal and vaginal examinations are important as foreign bodies tend to gravitate toward the pelvis. Tenderness may be a prominent feature. The wound may show signs of delayed healing. The *x*-ray is valuable in the diagnosis of this condition.

THE RETROPERITONEAL SPACE.

The retroperitoneal space is an imaginary one. It is a large area of loose connective tissue lying immediately beneath the peritoneum, following its numerous deflections and interposed between its folds. Its proximity to the peritoneum gives it much of its surgical importance. This area is well supplied with lymph nodes which are divided into three groups. The mesenteric glands lying in the folds of the mesentery drain the intestines more especially the small bowel. The group around the celiac axis drains the stomach, liver and pancreas. Drainage from the pelvis and lower extremities is accomplished by the lumbar nodes.

Lymphadenitis.—Lymphadenitis may be tuberculous or non-tuberculous (infective). The non-tuberculous variety come up in the course of acute infections, as complications of salpingitis, typhoid fever, buboes, etc. The infection in these cases comes through the lymph channels and involves the gland draining the area of primary infection. Appendicitis stands as the most common cause of suppurative lymphadenitis.

Infection in this region also occasionally follows labor and abortion. Hepatic, renal, pancreatic or splenic abscess, caries of the spine and ribs, pyelitis and foreign bodies are factors. The retroperitoneal space is involved by direct extension in some cases of peritonitis. This is especially true of the streptococcic type. Hematogenous infection is relatively rare. The last type explains the former idiopathic causes in which the primary focus was small, obscured and symptomless. The loose connective tissue underneath the peritoneum is easily susceptible to infection, because of its low resistive power and a cellulitis here may readily prove fatal. Many of the infections, however, are circumscribed, due in all probability to its abundant lymphatic tissue, and the tendency is toward abscess. Very large abscesses form in this region and are prone to gravitate toward the loin, or pelvis, pointing above Poupart's ligament, or in the lumbar region. An abscess may break through the peritoneum and cause a rapidly fatal peritonitis, or death may result from purely toxic absorption before peritonitis has had time to develop. Retroperitoneal abscess probably is more common than the records indicate, because of the difficulty in diagnosis in many cases.

Symptoms.—In well established cases, however, the condition is not difficult of recognition. There are the general symptoms of suppuration, loss of appetite and weight, general malaise, weakness, a cachectic appearance, fever sometimes as high as 105°, rigors and profuse sweats. The leukocyte count is high. The localizing symptoms may not be so clearly defined, because of its deep location. Tenderness and lumbar spasm are most always present. Spinal rigidity and a palpable fluctuating mass are occasionally observed. The most common cause of this condition is the appendix. As soon as the condition is recognized prompt drainage should be established. The drainage should be free and when possible the peritoneum should not be opened. This may be done by making an incision parallel to Poupart's ligament and gently dissecting up the peritoneum so as to avoid its rupture. The abscess can then be freely opened in safety. Rubber tubes are the best means to secure satisfactory drainage. The lumbar route is the simplest if the process can be reached through the loin. The bacteria most often accountable for retroperitoneal infections are of the colon family. The Staphylococcus aureus and others are sometimes found.

Tuberculous Lymphadenitis.—Tuberculous involvement of the retroperitoneal glands occurs most often in young life. Cows' milk, as well as other contaminated food is one of the chief causes. It may develop as an extension of tuberculous involvement elsewhere, or it may be a part of a general tuberculosis. Of all the glands the mesenteric group is most often affected. When these glands become enlarged and swollen the condition is known as *tabes mesenterica*. It is often associated with a chylous ascites. The glands around the terminal ileum and head of the cecum are often affected. Those around the stomach are seldom affected. The lymph nodes become enlarged and tender. The general symptoms of tuberculosis are usually present. In case the lymphomas become very large operation should be done for for their removal. Hygienic and *x*-ray treatments may be tried first. If the condition persists serious and possibly fatal complications may set up. Statistics show splendid operative results. The prognosis is far better when the disease is seen and treated in the early stages. Early pulmonary tuberculosis is not a contra-indication to operation. Often the individual lymphomas can be enucleated and the peritoneum sutured without drainage. This is an excellent procedure when it can be performed. Occasionally when the lymphomas are so large and numerous that enucleation would naturally damage the blood supply, resection of portions of the bowel, together with the tuberculous glands may be necessary. In case the glands have broken down and formed a large cold abscess, aspiration with the immediate injection of formalin in glycerin or of Beck's paste is indicated. Beck's paste is probably the best and the injection may have to be repeated from time to time before the cavity is entirely obliterated. If fragments of carious bone remain, the cavity will continue to drain until the sequestrum is removed.

Enlarged and palpable tuberculous glands have been mistaken for

malignancy. Sometimes a tuberculous gland lying near the spine resembles osteomyelitis or it may become calcified and show in an *x*-ray plate as a stone. The gland may become encysted on the one hand or become a large abscess and rupture intraperitoneally into a hollow viscus, or externally.

Hodgkin's Disease.—Late in the course of Hodgkin's disease the retroperitoneal glands may become involved. Over one-half of the cases occur in early life. The adenopathy begins in the cervical glands and the extension is progressively downward until the retroperitoneal glands are reached. Usually late in the course of the disease owing to the resemblance in the microscopic picture, Hodgkin's disease and lymphosarcoma have been confused. Hodgkin's disease seems to be essentially malignant. Coley believes it to be a form of sarcoma. Yates and Bunting have described the microörganism which they believe to be causative. In the late stages when retroperitoneal involvement occurs there is marked asthenia, cachexia and anemia. The spleen is enlarged and pressure symptoms as edema and jaundice may supervene. Its course is always toward a fatal termination. Occasionally the glands in this area may be affected primarily and the process remain confined to the retroperitoneal nodes for a long time. This is the localized form of the disease which is extremely hard to diagnose *intra vitam*. Should the lumbar glands or any of the other groups become involved primarily, they should be radically removed. Roentgentherapy is valuable. The specific vaccine may be employed.

Gumma.—Occasionally syphilitic gumma are found in the retroperitoneal tissue. It is an uncommon condition and for this reason should be mentioned. The patient may exhibit all the characteristics of lues, and a diagnosis then is readily made. However, the general symptoms of the disease may be masked and the complaint limited to a mass or tumor which is deep seated behind the peritoneum. In such cases the importance of a Wassermann is obvious. If the reaction of the first Wassermann is not characteristic and the nature of the mass is uncertain a provocative dose of arsphenamine should be given. This disease is only of diagnostic importance to the surgeon.

TUMORS OF THE PERITONEUM AND RETROPERITONEAL SPACE.

The peritoneum is seldom affected by malignant disease primarily. It usually occurs secondarily to cancer of the stomach, ovary and uterus. Probably the most common primary site from which peritoneal cancer may come is the stomach. The glands around the stomach are divided into four groups (Cuneo), subpyloric, retropyloric and glands of the greater and lesser curvatures. The uterus is drained by the lumbar nodes. Growths of the testicle metastasize to the iliolumbar group. If the disease is held in check by these various lymphatic groups it is of primal importance to remove them if possible, together with the primary focus. The ovary is often the primary focus for a

general carcinomatous involvement of the peritoneum. The entire peritoneum becomes studded with small whitish nodules which closely resemble tuberculous peritonitis. The structure of each nodule is similar to that of its parent growth. The condition is associated with ascites, the fluid being a straw-colored serum, or most commonly blood-tinged. The ascites is occasionally chylous in character, occurring in those cases where carcinoma has injured one of the lymph radicles. This type of peritonitis often occurs suddenly and is unexpectedly met during an operation for a cystic ovary. This condition is associated with rapid wasting and sometimes with fever and delirium.

Gelatinous cancer is a form of malignant growth which sometimes seems to be primary within the peritoneum. This type of carcinoma may originate within the mucous membrane of the colon. It often forms large masses of gelatinous material which may distend the peritoneal cavity to enormous limits.

Endothelioma or epithelial cancer occasionally involves the peritoneum and is worthy of mention. It springs from the endothelial cells lining the lymph spaces. The cells appear cuboidal or polyhedral under the microscope. The tumors are often circumscribed, of flattened neoplasms. Scattered over the surface of the peritoneum papillary fibromata of the peritoneum is secondary to that disease of the ovary. Occasionally multiple malignant cystic implantations of the omentum has been observed, due to transplants from cystadenoma of the ovary. Colloid or mucoid cancer is another type of malignancy which is associated with ascites. The ascitic fluid may require frequent tappings in order to keep the patient comfortable. When the fluid is withdrawn it is seen to contain small pieces of mucoid material which resembles "tapioca grains." In the last weeks of life movable tumors can be palpated throughout the abdomen. Diarrhea is usually a late symptom.

Lymphangio-endothelioma peritonei has been observed. It occurs as hard grayish plaques scattered over both the visceral and parietal peritoneum. It is accompanied by ascites.

Primary sarcoma involving the peritoneum is an extremely rare condition. Venable reported 1 case following trauma. The growth here, as elsewhere, is rapid. The tumor may be palpable and movable. The prognosis is grave since metastasis occurs early and recurrence is prone to follow operation. Associated with a rapidly growing movable tumor is nausea and vomiting, malaise, loss of weight and strength, and abdominal cramps.

Solid Tumors.—One of the most frequent solid tumors of the retroperitoneal space is lipoma. Other solid growths are fibromata, sarcoma, myxoma and fibrosarcoma. Harris analyzed 57 cases found in the literature. The majority occurred in males. In 1 of these series the sex was not known. The youngest case was a female child two years of age (Dickinson); the oldest case was a patient eighty-seven (Berthelot). Although they may occur at any period, statistics show that the majority are found in the fifth and sixth decades of life.

Upon a pathological basis the classification of retroperitoneal solid

tumors was made as follows: Carcinoma, 16 cases; lipoma, 10 cases; lipoma with calcareous masses, 1 case; myxolipoma, 3 cases; fibrolipoma, 1 case; fibroma, 2 cases; fibroma with calcareous degeneration, 1 case; fibromyxoma, with ossification, 1 case; osseous tumor, 1 case; fibrocartilaginous tumor, 1 case; chylangioma, 1 case; adenolymphoma, 1 case, and sarcoma 7 cases (fibrosarcoma, lymphosarcoma).

From the above table quoted at length from Harris and Herzog's article, it will be seen that the three most common tumors are: (1) carcinoma, (2) lipoma and (3) sarcoma.

Lipomata.—Probably the most common tumors of the retroperitoneal space are the lipomata. These tumors frequently invade the fold of the mesentery or omentum, although they may be found at any part of the abdominal wall. They frequently occur within the perirenal fat (about 33⅓ per cent.) and distort the kidney. The mesentery of the sigmoid is also a favorite site. Adami's classification as to origin was (1) perirenal and in one reported series 24 out of 42 were perirenal, (2) doubtful and (3) mesenteric. They occur more frequently in women than in men. Obesity has nothing to do with their etiology, so very large lipomas have been found in emaciated subjects. Lipomas are more frequently observed between the ages of thirty and sixty.

According to its composition lipomas are classified as pure lipoma (Begouin says over 50 per cent. are of this type), fibrolipoma or the tumor may undergo a myxomatous or sarcomatous degeneration. The latter condition is most apt to develop in a fibrolipoma. Occasionally a lipoma will become calcified or even contain osseous material. They sometimes become infected and form a large abscess. In 1 reported case an enormous lipoma enclosed a large abscess cavity in its lower anterior aspect, from which on aspiration 9 pints of sweetish pus was removed and about 60 pints were removed at other later tappings.

These tumors are found pedunculated or sessile and circumscribed. Owing to a degeneration of their pedicle by torsion, or in some other manner, the tumor sloughs from its attachment and is encountered free within the peritoneum at operation.

The precise origin of this type of tumor is from the subperitoneal connective tissue. They usually grow forward carrying over their surface the parietal layer of peritoneum, which gives them a glistening appearance. In this manner they may extensively invade the peritoneal cavity, as they often attain considerable size. In 1889 Mudd reported a retroperitoneal lipoma which weighed sixty-six pounds. The tumor was found at autopsy. The abdomen extended down on to the thighs.

In a few cases the smaller lipomas have been the cause of hernia, by growing through the canal or other points of least resistance lateral to the peritoneum. In this way they carry the adherent peritoneum with them, thus forming a hernial sac.

Symptoms.—Symptoms are mechanical and depend upon the size and position of the growth. In tumors growing out beneath Poupart's ligament there may be more or less pain in the leg from the stretching

of the nerve. These tumors presenting externally have a soft and boggy feel. The intra-abdominal type, as a rule, causes no definite pain, but usually a dragging, heavy sensation. By direct pressure on the stomach they cause a feeling of fulness. Gastric irritability is later followed by vomiting. There is usually no tenderness. In a case reported by Roux the patient suffered from recurring attacks of obstruction. Pressure upon the various venous radicles leads to edema and jaundice may supervene from occlusion of the common duct. Vomiting sometimes is a common symptom. The tumors are more or less movable and are covered by intestines. Dysphagia and frequent urination are further evidences of pressure. Lipomas may be confused with pelvic cysts. Hens says hypogastric tympany exists while the patient is in the Trendelenburg position in contrast to the dulness over a cyst.

These tumors when sufficiently large to produce symptoms should be removed. Primarily they are purely benign but like all other connective-tissue tumors, they are subject to malignant degeneration. In one reported case the tumor recurred after its removal. Waldeyer reported a case of lipomyxoma which weighed sixty-three pounds and in some places presented a sarcomatous structure. There were metastasis in the lungs and liver. The mortality in the past has been probably around 50 per cent. (Adami 53.9). Broca's patient in 1850 seems to have been the first case of fibrolipoma. The chief dangers in removing tumors of any size which have invaded the mesentery is injury to the blood supply of the small intestine and subsequent gangrene.

Sarcoma.—Seventy-one per cent. of the series reported by Steele occurred between the thirtieth and sixtieth years of life. The youngest case was a baby under one year of age, the oldest case was a woman past eighty. Sex seems to be of no significance. According to Steele in 19 cases the tumor was centrally located, while 18 were in the right lumbar region. This gives a total of 37 tumors on the right side of the abdomen, while there were only 19 occurring on the left side. These tumors in a majority of cases have their origin in the lymph nodes. Steele estimates this class of tumors to represent about 64 per cent. The minority then have their origin in connective tissue and compose the spindle-cell variety of sarcoma. The round-cell tumors arise in lymphatic structures. In many instances the growth springs from the capsule of the kidney. The various types of sarcoma have been found in this region. Reported cases have included about eight types, as follows: (1) small round cell; (2) large round cell; (3) spindle cell; (4) polymorphic type; (5) lymphosarcoma; (6) giant cell; (7) alveolar; (8) angio- and myxofibrosarcoma.

Occasionally a sarcoma may contain unstriped muscle tissue, but this is contained in the retroperitoneal space.

These tumors metastasize early in the liver, kidneys, spleen, lungs, skin, etc. The most common sites for metastasis is the liver and lungs. Metastasis, however, does not occur in all cases.

Sarcoma usually occurs as a solitary tumor of rapid growth. The average duration of life is said to be seven or eight months. These tumors present certain characteristics. The growth is usually hard and firm but may be more or less elastic. It has a white and glistening surface which latter is produced by the peritoneum. The tumor may be round or nodular, and often is encapsulated, but is prone to degenerate. The degeneration begins in the center and a sarcomatous cyst may result.

Waldeyer has described a special form of sarcoma to which he has given the name angiosarcomaplexiform. In this type of sarcoma new bloodvessels, which have formed, undergo colloid degeneration of the vessel wall, which produces a peculiar gelatinoid tumor.

Symptoms.—There is usually an insidious onset. Pain is indefinite and there is some discomfort after eating. Nausea may be present in some cases and even vomiting. The pain in most instances becomes progressively worse. The rapid growth of the tumor is accompanied by loss of flesh and appetite, malaise and cachexia. Most of the symptoms may be referred to the stomach as nausea, pain after meals and vomiting. In this locality the tumor is usually fixed, but it may be movable. In Rogowski's case the patient complained of pain in the right foot. The tumor was situated in the right iliac fossa. In another reported case a sarcoma penetrated the urinary bladder and the patient passed blood and bits of tissue through the urethra. Ascites is rarely present. Diarrhea may be a persistent symptom. Sarcoma in the retroperitoneal space bears a more grave prognosis than the intraperitoneal variety. The growth is prone to invade the soft tissues and in some cases metastasis is an early occurrence and degeneration is early and common. In spite of the grave prognosis, if the cases are seen early, they should be operated upon. It is not always practicable to diagnose the particular type of tumor with which you are dealing. A diagnosis of new growth in the retroperitoneal space should at least suggest sarcoma, since it is fairly common, relatively speaking. In a series of solid tumors of the omentum, 11 were sarcoma. Early degeneration, infiltration of the soft tissues and metastasis may produce an inoperable condition almost from the beginning. Without operation death results usually in from seven to eight months. Pean removed a tumor weighing fifty pounds from the retroperitoneal space and the patient recovered. In a series of 18 operations 10 recovered. This series, however, probably, included all types of neoplasms. In 1885, Cleaver Woods was successful in removing a sarcoma (cystic type) weighing two and one-half pounds from a child eighteen months old. In a list of 84 cases there were 12 operations and 10 recoveries. Prompt and radical surgery is the desideratum. Fortunately the growths in the beginning are encapsulated. The approach, in view of the difficulty, oftentimes impossibility of differential diagnosis should be from the front. The other forms of tumors occurring in the retroperitoneal space, such as fibroma, myxoma, enchondroma, etc., are exceedingly rare and are of no particular importance, except where they produce symptoms by their size.

Cysts.—Retroperitoneal cysts are about as common as solid tumors The *echinococcus* cyst is rare, usually secondary and generally lies in the omentum. It may involve the mesentery. The cyst may be single and large, or multiple and of various sizes. These cysts sometimes become very large, especially when primary. In the cyst there may be a pedicle attaching them to the peritoneum and in such cases removal is easy and complete. If the cyst is not pedunculated the method of Deve may be applied. The contents of the cyst should be withdrawn by means of a two-way aspirator, which permits of the immediate injection of formaldehyde, 5 to 10 per cent. solution, into the cyst, following aspiration. Later the cyst is opened and as much as possible of the sac is excised. Then sutures are applied so as to reduce the cyst. Cases of echinococcus cysts are reported in which the sac was enormous, extending from the navel to the bottom of the pelvis and containing daughter cysts as large as cocoanuts.

The *simple cysts* are the common variety. They occur more frequently than tumors and usually involve the omentum or mesentery. According to Hahn the primary cysts are either chylous cysts or blood cysts.

Chylous cysts of the mesentery are exceedingly rare. There are only about 20 cases in the literature and 29 serous cysts reported. There is a wide difference of opinion as to their origin. Dowd maintains that chylous cysts are of embryonic origin. Moynihan thinks that the causes which produce these cysts are manifold. A patient may be a victim of trauma, which ruptures a chyle vessel, and a chylous cyst then develops (Rasch's case). On the other hand, the cyst may result from a degenerating lymph gland or from dilatation of the lymphatics. Von Blum thought probably that degeneration of the mesenteric lymph nodes due to tuberculosis or typhoid might play some part in their etiology. Dilatation of the receptaculum chyli is no doubt the origin in a few cases. The distinguishing feature between chylous cysts as regards their origin, seen under the microscope, is the presence or absence of endothelium unless obliterated by pressure. In case of cyst resulting from a dilatation of lymph sinuses or lymphatic glands, the cyst wall will have an endothelial lining, but in cases where trauma has produced rupture into the cellular tissue with chylous effusion and cyst formation, this lining endothelium will not be present. These cysts may be single or multiple, unilocular or multilocular. The walls are of a creamy color and generally contain large vessels. Rarely there is a pedicle. The great majority of chylous cysts develop within the mesentery. Cysts in the mesentery cause more pain than any other abdominal cyst, and may also cause recurring attacks of volvulus. The diagnosis is not always easy. They may be mistaken for ovarian cysts. In one reported case an operation was performed for tuberculous peritonitis and a chylous cyst found and successfully removed.

Blood cysts are usually the result of trauma, from hemorrhage into a cyst, or from hemorrhage into a softened tumor. Occasionally a hemor-

rhage will take place into the general peritoneal cavity, from the site of a ruptured Graafian follicle during straining at vomiting, etc., from rupture of varicose veins in the broad ligament or from a uterine myoma. This hematoma may become encysted. Other rarer forms of cysts are angiomata and enchondromata. The *cysticercus cellulosæ* is occasionally found in the connective tissues of the retroperitoneal space. The symptoms produced by cysts vary with their size and location and are mechanical only. A cyst lying in the mesentery will be found below and to the right of the umbilicus, unless it is in the mesentery of the first part of the jejunum, or in the sigmoid. Primary cysts may reach great size.

Epithelial cysts are occasionally observed. They develop from the remains of the omphalomesenteric duct. Remains of the Wolffian and Müllerian ducts may also become cystic. They can sometimes be removed through a lumbar incision. If the entire cyst is not removed a fistula will result. In the case of primary cysts the contents should be evacuated and as much of the cyst wall as possible removed. The part that is left should be stitched to the abdominal wall and kept packed until obliteration occurs.

Teratoma.—Teratoma of the peritoneum are rare. Lexer gives the following classification: (1) Simple and complex dermoids; (2) fetal inclusions and (3) teratoid mucous tumors. Simple dermoids are found in the mesentery behind the peritoneum. The complex dermoids arise from the ovary and from an undescended testicle and lie within the pelvis. Fetal inclusions are found within the transverse mesocolon or in the omental bursæ. The teratoid mucous tumors are either solid or polycystic and are made up from the three embryonal layers. They are removable through an abdominal section. This should always be done as they are prone to both suppurative changes and malignant degenerations.

DIFFUSE SEPTIC PERITONITIS.

By HERBERT A. BRUCE, M.D., F.R.C.S., Eng.

The variations in the application of the term *general peritonitis* have led to much confusion, and have greatly diminished the value of the statistics. The results of pathological investigation indicate that in acute infection of the peritoneum general diffusion of the exudate throughout the peritoneal cavity rarely occurs, and that in such cases, more especially those associated with perforative appendicitis, the internal organs, with their ligaments and mesenteric attachments, tend to prevent and delay extension. The term *diffuse peritonitis* applies only to cases in which there are no limiting adhesions, and the clinical course is of a progressive character. Rauenbusch[1] distinguishes a supra-omental and an infra-omental form, extension occurring from above downward and from below upward respectively. The most common form is that limited to the portion of the peritoneal cavity below the transverse colon. From a clinical point of view it is incorrect to regard diffusion of the exudation over the whole of the peritoneal cavity as a necessary concomitant of diffuse peritonitis, because in the first place what may be correctly described as universal peritonitis is rare, and is seldom met with, even on the operating table. In the second place the severity of the clinical course is by no means always proportionate to the diffusion of the exudation, as some of the cases in which the pus is by no means widely diffused run a very severe course, and end fatally in spite of the most careful treatment. A definite separation into localized and general peritonitis therefore appears to be a more or less arbitrary classification, and in view of the difficulty of making a definite clinical diagnosis of generalized peritonitis, *diffuse peritonitis* is in my opinion a more suitable designation for these cases than general peritonitis. The most satisfactory and practicable classification, from the point of view of statistics, is to separate the cases which come to operation into the early and late stage, the early stage including those operated upon within the first forty-eight hours—or better still twenty-four hours—after the onset of the attack, and the late stage those operated upon from the third to the fourteenth day or later.

Etiology.—The causes which may be influential in setting up peritonitis are manifold. By far the most common form of septic peritonitis is that associated with disease of the vermiform appendix, and the increase in the knowledge of the pathological anatomy and

[1] Cited by Kron: Arch. f. klin. Chir., 1910, xciv, 1105.

symptomatology of appendicitis has therefore greatly contributed to the reduction in the mortality of peritonitis. The next cause in order of frequency is perforation of ulcer of the stomach or duodenum, the prognosis of operation in both these and the appendicular cases being fairly good, provided operation can be undertaken at an early stage. The peritonitis arising from perforation of a gastric ulcer usually runs a milder course and has a better prognosis than that due to perforation of a duodenal ulcer, owing to the fact that the acid reaction of the gastric contents tends to arrest the development of the infective agent.

Other causes which may result in peritonitis are perforation of the intestines from typhoid or other cause, perforation of the gall-bladder, wounds of the abdomen involving the digestive tract, and infection extending to the peritoneum through the Fallopian tubes. The most severe forms of peritonitis are those associated with spontaneous rupture or traumatic perforation of an abdominal viscus, and those originating from the appendix, both of which rapidly become generalized, the diffusion of the infective material being especially rapid in perforation of the stomach or intestines. Everything, therefore, depends in such cases upon the promptness with which operation can be undertaken.

In considering the peritonitis originating from perforation of the gall-bladder, which is usually assumed to be extremely grave, a distinction should be made between that due to perforation of a gall-bladder, the contents of which may be regarded as sterile, and that originating from perforation of a gall-bladder containing pus. The former is comparatively benign, while the latter is an extremely malignant and dangerous condition. The prognosis is also influenced by the fact that the bile appears to have an unfavorable effect upon the serosa, considerably reducing its capacity for resistance to the invading microörganisms. The same may be said of the contents of the small intestine, after perforation of which the peritoneal serosa exhibits severe changes.

Cases have been reported from time to time, in which peritonitis supervened without perforation of the gall-bladder, and the condition has been attributed to an abnormality in the macroscopically intact walls of the biliary duct due to various causes, including biliary stasis, gangrene of the bladder, non-perforating traumatism and infection. Cases of diffuse septic peritonitis originating from acute pancreatitis without any visible perforation have also been reported, the peritonitis being practically universal. Cases of diffuse peritonitis, associated with acute appendicitis without perforation of the appendix, are not infrequently met with. Three cases of paratyphoid peritonitis have been recently reported, in none of which could a perforation be discovered. In these cases it may be assumed that the peritonitis was due to the penetration of the paratyphoid bacillus through the macroscopically intact intestinal wall.

There is some diversity of opinion as to whether there is such a

thing as pure gonococcal peritonitis. Many surgeons believe that the gonococcus alone, is capable of setting up peritonitis, but others, including Bumm and Fromme,[1] deny this absolutely, and think that it can do so only when associated with other microörganisms, most often streptococci.

In regard to gonorrheal peritonitis a distinction should be made between that due to rupture of or leakage from a sterile pyosalpinx, and that due to rupture of a pyosalpinx containing active gonococci or streptococci. In the former case the course of the condition is comparatively benign, and tends toward retrogression and recovery. Many such cases recover with rest only, and this may possibly explain the good results which have sometimes been reported from the internal treatment of peritonitis. Recovery may be due to one of the following conditions: (1) The disappearance of the germs, especially streptoccoci, in anaërobic cultures; (2) impairment of the vitality of the gonococci by the action of the toxins which they produce, and which ultimately render them innocuous.

In the second form of gonorrheal peritonitis we are dealing with an acute, virulent, diffuse peritonitis, due to leakage from or rupture of a tube recently infected by the gonococcus, and the condition produced is therefore much more grave, and much more likely to run an unfavorable course, as the germs, whether gonococci alone or gonococci and streptococci, immediately find a favorable medium for growth in the toxic contents of the pyosalpinx. This second variety of gonorrheal peritonitis is illustrated in the case of a patient who came under my observation some years ago.

She was a young married woman, aged twenty-six years, who had been infected by her husband. Two weeks after infection she developed a pelvic peritonitis, which in two days had become diffused throughout the abdomen. On the third day she was acutely ill, with intense rigidity of the entire abdomen, a temperature of 105° F., and a pulse of 140. The abdomen was opened and drained. Her symptoms were septicemic, and she died three days later.

I should like to refer briefly to pneumococcal peritonitis, which is a very rare condition. Netter,[2] who examined 140 cases of peritonitis bacteriologically, found the pneumococcus in only 2 cases. It may be primary or secondary, and occurs more often in women than in men. Cases of pneumococcic peritonitis not infrequently develop septicemia.

Formerly we were accustomed to hear of postoperative peritonitis, but this should never occur. Scrupulous attention to technic, and above all the covering of the hands of the operator by rubber gloves during operation, has added greatly to the safety of peritoneal operations. By substituting asepsis for antisepsis the defences of the serosa are preserved in their integrity. The perfection to which technic has now been brought prevents the entrance into the peritoneal cavity of

[1] Cited by Clarke: Am. Jour. Med. Sc., 1913, cxlv, 306.
[2] Cited by Wharton: Ann. Surg., 1910, lii, 274.

germs from the digestive tract, the tubes or the ovaries. This includes the carrying out of the greater part of the operation before the opening of the septic cavities, reduction to a minimum the time during which they are open, and exact limitation of the field of operation.

Bacteriology.—There is still considerable difference of opinion as to whether the bacteriological findings have any material influence on the prognosis. The results of the researches which have been carried out in this connection have, up to the present, not revealed any specific microörganism which invariably sets up peritonitis. They indicate that in the majority of cases a mixed infection is responsible, due to the association of external bacteria with the usual intestinal flora, and there is no evidence to show that any one microörganism is more often the predominant factor in the production of the symptoms than another.

Haim[1] has published the results of extensive investigations, and states that they indicate that the rare cases of pure streptococcal and pneumococcal infection produce severe constitutional symptoms, are frequently associated with a slightly abnormal appendix, run a particularly severe course, and have a higher mortality than other varieties of peritonitis, especially the cases associated with a pure infection by the colon bacillus. He finds that streptococci and pneumococci predominate in cases in which there is general involvement of the cavity, while the colon bacillus alone is most often met with in the encapsulated variety of peritonitis. The comparative mortality of streptococcal and pneumococcal peritonitis, operated upon at an early stage, is more than three times as great as that of colon bacillus peritonitis, and nearly twice as great when operated upon at a late stage. Haim reports 27 cases of peritonitis with 14 deaths. Streptococci were demonstrated in 9 of these cases, 8 of which ended fatally. When infection is due to the streptococcus or pneumococcus death usually results from the infection alone, while in other cases the patients more often die from intestinal obstruction, embolism, thrombosis or pneumonia.

Haim, therefore, distinguishes two varieties of peritonitis, namely, that due to streptococci or pneumococci, in which the appendix is used only for the passage of the microörganisms, without producing perforation or gangrene, and that due to Bacillus coli, in which there are severe changes in the appendix. As regards streptococcal and pneumococcal peritonitis, Giertze[2] does not believe that it is possible for bacteria to pass through the intact intestinal wall, and supports this statement by a reference to cases of gastric ulcer, typhoid, dysenteric and tuberculous intestinal ulcers and mechanical ileus, in which, in spite of changes in the intestinal wall and deep ulceration, septic peritonitis does not occur. The results of Weil's investigations indicate that, although the intestinal wall may be macroscopically intact, it is normally not completely impervious to bacteria, and

[1] Arch. f. klin. Chir., 1912, xcix, 1067.
[2] Cited by Haim: Loc. cit.

that although, as a rule, the peritoneal cavity is well protected from infection by the normal intestinal flora, the conditions are quite different when virulent external bacteria enter the intestine and set up enteritis. He found that virulent streptococci and pneumococci, introduced experimentally into the intestinal canal, constantly set up peritonitis. A number of cases of diffuse septic peritonitis are met with, in which no macroscopical perforation or lesion can be discovered in any part of the intestinal tract, but we cannot say positively that a microscopical lesion does not exist. In such cases we assume that the bacteria gain access to the peritoneal cavity by means of the lymphatics or blood stream.

Haim's observations indicate that sore-throat is common in streptococcal and penumococcal cases, and is also sometimes met with in other forms of peritonitis. It frequently precedes streptococcal peritonitis, and streptococci are often present both in the pharyngeal deposit and the peritoneal exudate. Pure streptococcal and pneumococcal cases are most often observed in comparatively young people. Haim's opinion in regard to the severe clinical picture of streptococcal and pneumococcal peritonitis, its bad prognosis and more common occurrence in young people, is confirmed by many writers, including Murphy and Körte.

Dudgeon and Sargent[1] have pointed out that peritonitis due to microbic infection represents a protective reaction of the peritoneal serosa. They find that cases which recover, if examined bacteriologically, almost invariably exhibit primary infection by the Staphylococcus pyogenes albus, and they therefore regard the peritoneal fluid containing this organism as being of a protective nature.

On the other hand Mr. Rutherford Morison,[2] at the Meeting of the British Medical Association in 1911, stated that in his opinion the nature of the infective agent is of practically no significance in relation to prognosis, and Noetzel agrees with this. Noetzel[3] states that recovery has occurred in several cases of pure streptococcal infection which have come under observation at Rehn's Clinic, and he thinks that cases of this variety are so rare that the number is not sufficiently large to allow of a satisfactory comparison with regard to prognosis. He also points out that infection by the colon bacillus may be exceedingly severe, and that many patients die from it.

Symptoms and Diagnosis.—The clinical picture of diffuse septic peritonitis varies considerably, as the majority of the symptoms may be present or absent in individual cases. The following are the most important symptoms:

1. Abdominal pain and tenderness, on pressure, at first localized, soon becoming diffused.
2. Muscular rigidity, at first localized, later general.
3. The pinched and anxious expression of the face, known as *Hippocratic facies.*

[1] Lancet, February 25, 1905.
[2] British Med. Jour., 1911, ii, 1066.
[3] Arch. f. klin. Chir., 1909, xc, 619.

4. Vomiting, which recurs at short intervals.
5. Drawing up of the legs, with the object of relieving pain.
6. Increased pulse-rate and elevation of temperature.

The most reliable sign, from the point of view of diagnosis, is the so-called "muscular defence," or abdominal rigidity, the degree of which renders it possible to determine the extent of involvement of the peritoneum. It must be borne in mind, however, that even this symptom may be absent in certain exceptional cases, and that it also occurs in pneumonia. The symptoms next in order of importance are pain and tenderness on pressure. In appendicular peritonitis a history of *perforation pain* is significant, in that it frequently indicates the time of onset of the peritonitis. On the other hand Zander[1] has observed several cases which indicate that a sudden cessation of previously existing pain almost certainly points to peritonitis. When the peritoneum is generally involved vomiting becomes frequent. The condition of the pulse and temperature are not reliable signs as to the extent or severity of the peritonitis. In some very severe cases the pulse-rate is under 100, and the temperature is raised only 1 or 2°, whereas in slighter cases the pulse-rate may be increased to 110 or 120, and the temperature be as high as 103°. While peritonitis *may* be present, however, when there is only a slight increase in pulse-rate and a slight rise in temperature, a very high temperature and a very rapid pulse-rate naturally indicate a severe form of the disease. In the late stage the clinical picture of peritonitis often resembles that of intestinal obstruction.

In peritonitis due to rupture of the intestines the character of the rigidity may be a valuable guide, as that due to contusion of the muscles alone usually disappears within a few hours. Immediate operation should be undertaken if the following indications are present: Severe pain persisting for more than six hours, if accompanied by vomiting, a rising pulse, progressive local rigidity, deep local tenderness on superficial respiration.

In the peritonitis of perforating gastric or duodenal ulcer there is usually in the first place localized epigastric pain, and often pain in one or both shoulders. This is generally accompanied by profound shock, the patient frequently breaking out into a cold perspiration. The scaphoid and rigid abdomen is one of the most characteristic signs of perforation peritonitis. When severe distention appears it indicates a stage of peritonitis so advanced that recovery can scarcely be expected to result from any form of treatment.

If the symptoms and signs lead us to the conclusion that some form of peritonitis is present, we must next endeavor to discover its source of origin. In this connection the history given by the patient is often of great value, and a careful inquiry should be made as to the exact site of the early pain, as this, together with the point of maximum tenderness on pressure, will probably afford a valuable

[1] Arch. f. klin. Chir., 1914, cii, 944.

indication as to the condition which has given rise to the peritonitis. For instance, in perforation of the stomach the patient generally states that pain was first felt in the epigastric region, and on examination the point of maximum tenderness on pressure will be found to be over the site of the perforation. Even at a late stage the maximum pain, tenderness on pressure and rigidity will usually be localized at the point of perforation. What has been said also applies to the duodenum and gall-bladder, but their near neighborhood may render it more or less difficult to decide as to which of them is the seat of the lesion. If, on the other hand, the appendix is responsible for the peritonitis the early pain will be localized at a much lower level and tenderness on pressure and early rigidity will be greatest over the site of the appendix.

In this connection the age and sex of the patient are of importance. In males under twenty years the appendix is most frequently at fault. After twenty, gastric, duodenal or intestinal perforation should be taken into consideration, and as age advances the probability of perforation of the gall-bladder or perforation of the intestines from cancer increases. Pneumococcal peritonitis is more common in girls than in boys, and in women inflammatory conditions of the genital organs should be taken into consideration in making the diagnosis.

Prognosis.—A very important factor in the prognosis after surgical interference is the defensive reaction of the peritoneal serosa, which renders it possible for it to deal with a considerable amount of septic material. Prognosis is obviously more favorable if operation is undertaken before the onset of toxemia, and before the resistance of the patient is seriously impaired. Rutherford Morison states that the prognosis is good if the heart is strong, the pulse of good volume and not over 100, but that it is invariably bad if cyanosis is present, the extremities are cold, and the pulse is over 120. When operation is undertaken a more or less correct prognosis can usually be made from observation of the condition of the intestines. Grekow,[1] who has had considerable experience in dealing with cases of peritonitis, says that, judging from his experience, the dry form of peritonitis is absolutely hopeless, whatever the treatment employed. The chief factors which influence the prognosis are the degree of peritoneal toxemia, the severity of the primary disease, and the time which elapses between its onset and the operation.

There has recently been a considerable amount of discussion as to whether all cases of peritonitis should be operated upon or not. Some are of opinion that if there is little or no hope of saving the life of the patient relief of pain only should be attempted, while others maintain that it is absolutely impossible to be certain that recovery may not follow operation, even when a patient is apparently moribund. It must be said that there are cases of ultraseptic infection of the peritoneum in which operation is practically useless. These cases

[1] Beiträge z. klin. Chir., 1914, lxxxix, 291.

run a rapid course, and the defensive reaction of the peritoneum is so slight that they may be described as septicemia rather than peritonitis. Even in these desperate cases, however, operation is indicated if it represents the only chance for the patient, in spite of its almost invariably fatal results, and in some of these cases, operated upon by the writer when the patient was practically *in extremis*, recovery has resulted. It cannot be too strongly emphasized that delay in operation is responsible for most of the fatalities which occur. In cases which are too far advanced to allow of removal of the cause of the peritonitis, a certain amount of relief may follow drainage of the abdomen by means of one or two small incisions.

Increased simplicity and rapidity in operation have undoubtedly greatly contributed to the reduction in mortality. Twenty years ago extensive flushing and evisceration were practised, the mortality being from 40 to 50 per cent. or even more, but it is now unanimously agreed that these severe methods of treatment have had their day, and they have accordingly been abandoned.

Treatment.—In 1880, Mikulicz[1] operated for the first time upon a perforating gastric ulcer, and suggested the possibility that laparotomy might be beneficial in diffuse perforative peritonitis. Lawson Tait,[2] in 1883, and Leyden,[3] in 1884, also recommended operative treatment, but in spite of this Schlange,[4] von Bergmann's assistant, in a paper published in 1884, strongly emphasizes the inadvisability of laparotomy in the treatment of the condition. In 1886, Krönlein[5] advised immediate operation in perforation peritonitis, and expressed the opinion that, in view of the uniformly unsatisfactory results of medical treatment, recovery in one case out of many would warrant the adoption of surgical measures, but the first statistics of operative treatment were not published until 1890, when Stuhler, of Strassburg, collected 78 cases of drainage of the peritoneum.

A little more than twenty years ago recovery from diffuse septic peritonitis occurred only in exceptional cases, a diagnosis of peritonitis was practically equivalent to a sentence of death, and as a rule operation only accelerated the fatal termination. Scarcely any other disease can be mentioned, the mortality of which has been so greatly reduced by changes in treatment, and there is no doubt that great progress has been made in the treatment of all forms of peritonitis, more especially during the last ten or twelve years. Ten or fifteen years ago operation was undertaken only in cases of diffuse peritonitis in a very advanced stage, already complicated by toxemia, in which the prognosis was, therefore, practically hopeless. Improvement in methods of diagnosis has resulted in patients coming under the observation of the surgeon at an earlier stage of the disease, in many cases within a few hours after the onset of the symptoms.

[1] Cited by Bevan: Jour. Am. Med. Assn., 1911, lvi, 1184.
[2] Cited by Noetzel: Loc. cit.
[3] Deutsch. med. Wchnschr., 1884, No. 14.
[4] Cited by Bevan: Loc. cit.
[5] Cited by Noetzel: Loc. cit.

The extensive experience of many surgeons has conclusively proved that a rational operation, undertaken at an early stage, when the condition is still comparatively localized, will save many lives. There is up to the present no effective medical treatment of peritonitis, and the general reduction in mortality shown by recent statistics indicates that the advances in modern surgery have rendered recovery possible in a condition which was formerly regarded as practically incurable.

Prophylaxis is a very important part of the treatment of peritonitis. The general prophylactic treatment consists in the early diagnosis of conditions which may lead to peritonitis, and the removal of the source of infection with as little delay as possible. Mortality has recently been very much reduced by the early recognition of appendicitis, which is by far the most common cause of peritonitis, and the removal of the appendix before the inflammation has extended to the peritoneum. In the rare cases in which the onset of peritonitis is coincident with perforation of the diseased appendix, disease of which has previously been latent as regards the production of symptoms, operation should be undertaken before inflammation of the serosa becomes very severe and extensive. The view is now generally accepted that if possible every case of acute appendicitis should be operated upon within a period of twenty-four hours after the onset of the attack, and that early operation is the chief factor in the reduction of mortality and the prevention of severe complications, such as diffuse peritonitis. It is highly desirable to diagnose appendicitis before peritonitis has set in, and with the improved methods of diagnosis now at our disposal it is usually possible to do this. I should like here to emphasize the importance of a very rapidly performed operation, carried out without undue shock to the patient. A diagnosis of the probable cause of the peritonitis should be made before the commencement of the operation, so that, whether it be a perforated appendix, gastric or duodenal ulcer, etc., the condition may be speedily dealt with and drainage provided.

All surgeons are now agreed that operation is invariably indicated in all cases of diffuse peritonitis, and if there is no contra-indication laparotomy should be undertaken in all cases in which its presence is suspected. This general consensus of opinion, together with the improved technic of operation and methods of after-treatment, have greatly contributed to the reduction in mortality. Early operation has frequently revealed the presence of advanced peritoneal inflammation and purulent exudation in cases in which the only symptoms were localized pain and rigidity. In peritonitis due to rupture of the intestine the symptoms may be very indefinite, and their onset is frequently delayed for some time after perforation has occurred. In such cases rigidity, which is, as a rule, the most characteristic symptom of peritonitis, may be completely absent. I should like most emphatically to express the opinion that under such circumstances morphin should never be given until the diagnosis is made and a definite plan of treatment decided upon. As morphin relieves

the pain, it may lead to the delay of the operation for several hours or even indefinitely. This delay will naturally result in increase of the toxemia, and if sufficiently prolonged will make it impossible to perform an operation with much prospect of success.

Surgery is the only treatment for typhoid perforation peritonitis, and recovery is usually dependent upon operation being undertaken soon after the occurrence of the perforation. In the more severe forms of gonorrheal peritonitis operation may be performed with a favorable prognosis if no germs are present in the blood, but otherwise death is practically certain, whatever the treatment employed. At the same time no case of acute gonorrheal peritonitis should be allowed to die without being given the chance of operative cure, and if there is no improvement in the general and local condition in the course of a few hours, operation should be undertaken without delay.

The only exception to the rule of early operation is pneumococcal peritonitis, in which it is advisable to delay operation until an abscess has formed, as fatal results have frequently followed surgical intervention at an early stage. There is a tendency to encapsulation, and to limitation of the infection by the formation of adhesions. The treatment consists of incision and drainage.

The peritonitis resulting from wounds received in battle is naturally exciting a considerable amount of interest at the present time. Beavis and Souttar[1] have published a report in regard to the conditions prevailing in the British Field Hospital in Belgium. In dealing with abdominal wounds they point out that, while in the South African War the intestines frequently escaped injury altogether, or the lesions were limited to minute punctures, in the great war extensive laceration of the intestines was the rule, and in most of the cases the intestine was cut almost or completely across. Even if this did not occur the punctures represented large ragged holes. The result was that spontaneous recovery was possible only in very few cases of injuries of this kind. When brought to the hospital most of the patients were suffering from severe shock, and for this preliminary treatment was given, consisting of morphin, saline infusions, and injections of coffee and brandy, operation being performed half an hour later. Their experience indicates that in no case, even the most desperate, was there not a chance of recovery, the results being especially encouraging in cases operated upon within six hours. They have never seen a case of intestinal injury recover without surgical treatment, and are of opinion that it is invariably indicated and in fact imperative. The risks of laparotomy are trifling as compared with those incurred by delay.

Technic of Operation.—As regards the incision, if a diagnosis has been made, it is, of course, made over the site of the primary lesion. In doubtful cases it should be made in the middle line, immediately below the umbilicus. If this reveals no lesion, it is easily prolonged

[1] British Med. Jour., January 9, 1915, p. 63.

in an upward direction, so as to expose the stomach, duodenum and gall-bladder. If after making a median incision the appendix is found to be responsible for the trouble a second incision is made on the right side if necessary. During operation the patient should be kept warm, and unnecessary manipulation of the intestines avoided. The details of the technic are of far less importance in relation to the results than the time which has elapsed since the onset of symptoms.

Among the most influential factors in the improvement of the results of operations are:

1. The general adoption of Fowler's semi-sitting position, which facilitates drainage of the peritoneal cavity.
2. The injection of large quantities of saline solution, either by the subcutaneous or transrectal method.
3. Lavage of the stomach.
4. Reduction of the duration of the operation to a minimum, and consequent avoidance of unnecessary shock.

The objects of operation are:

1. The removal of the primary focus of disease, from which the peritonitis has originated, *e. g.*, a gangrenous or perforated appendix, or closure of a perforation.
2. To provide for drainage.

Suitable provision for drainage tends to prevent the further resorption of infective material into the blood stream, while the resulting reduction of intra-abdominal pressure facilitates respiration and circulation. With the object of increasing the rapidity and simplicity of the operation some writers have recently recommended that under certain circumstances the removal of the cause of the peritonitis should be abandoned, but it is still the general opinion, in which I concur, that the appendix should be removed in practically all cases of appendicular peritonitis, and all pus pockets broken up, the operation being carried out with the least possible manipulation of the intestines. This rule should, however, apply only to cases in which the operation is undertaken by a surgeon of wide experience.

Toilet of the Peritoneum.—The question as to how the exudation shall be dealt with after the cause of the peritonitis has been removed has given rise to a considerable amount of discussion, the alternatives suggested being as follows:

1. That it should be left in the peritoneal cavity.
2. That it should be flushed out.
3. That it should be mopped out.
4. That flushing should be practised in some cases, mopping in others.

The answer to this question is obviously dependent upon the importance which is attached to the thorough cleansing of the peritoneal cavity from the septic products present in it.

Von Haberer and Clairmont[1] have shown that the peritoneal serosa

[1] Jour. de Chir., 1910, v, 732.

manifests the greatest capacity for resorption at the level of the subdiaphragmatic spaces, and its defensive reaction in regard to infection has also been demonstrated. The great omentum, which is very movable and abundantly supplied with lymphatics, plays an important role in the defence of the peritoneum, as does also the natural tendency, which is present in many instances, for the inflammation to become encysted.

The old plan of treatment consisted in flushing out the abdomen, and as a matter of fact some surgeons went so far as to practise evisceration in order to accomplish this more thoroughly. These severe measures need only be mentioned to be condemned, as the injury thereby inflicted upon the delicate peritoneal endothelium tends to increase its capacity for resorption, and thus to produce a profound toxemia, a condition which has been assumed to be largely responsible for the frequency of fatal ileus. A more favorable medium is also produced for the growth of pathogenic bacteria. In addition it is, in the majority of cases, impossible to decide whether the peritonitis is universal or not, and if it is not, flushing is practically certain to result in more extensive diffusion of the exudate.

In my opinion the one essential point is that the primary cause of the condition should be removed with as little delay and injury to the peritoneum as possible, and with a minimum amount of narcosis. As the exudation itself possesses bactericidal properties, and is therefore an important factor in defence, it appears inadvisable to attempt its removal from the peritoneal cavity. In addition its complete removal can scarcely be accomplished without trauma. I therefore abandoned the practice of flushing out the abdomen many years ago. Neither am I in the habit of mopping out the pus, but my object in these cases is, first of all, to remove the cause of the peritonitis, and, secondly, to provide adequate drainage. It seems reasonable to assume that flushing and mopping tend to reduce the protective forces of the serosa, as represented by the leukocytes, and that it is better to leave the toxic material, which still remains in the cavity, to be dealt with by the natural resistance and resorbent capacity of the serosa. The fibrinous or fibrinopurulent deposits, which are in some cases observed on the intestines, should also not be interfered with. One of the great advantages of the dry method, as compared with that of flushing out the peritoneal cavity, is that it occupies much less time and thus tends to minimize shock. Since adopting this method my results have been infinitely better than when I wasted time in flushing out the abdomen.

Some surgeons, however, still maintain that great service is rendered to the organism by removal of as much of the septic material as possible, and think that while flushing is suitable in some cases, mopping is preferable in others. Most of the advocates of flushing reserve it more or less for cases in which the peritonitis has reached an advanced stage before operation is undertaken.

Drainage.—In regard to drainage, Lücke[1] was the first to insert a large drainage tube in Douglas's pouch in a case of peritonitis. The majority of surgeons are of opinion that it is advisable to make provision for the escape of the septic products left in the peritoneal cavity and of any exudation which may subsequently form, but that the arrangements for drainage should be as simple as possible, consisting of one drainage tube in the area of primary infection, and another in Douglas's pouch. Cigarette drains are preferable to unprotected rubber tubes. Murphy, however, insists on the importance of tubular drainage. At the Meeting of the British Medical Association in 1911, Mr. Leonard Bidwell[2] recommended rectal drainage, but I consider this objectionable.

The question of effective drainage of the peritoneal cavity is complicated by the fact that in the course of a few hours fibrinous exudation occludes the orifices of the drainage tubes. Drainage, therefore, continues only for a short time, perhaps twenty-four hours being about the maximum period. If the exudation is comparatively thick and contains large quantities of fibrin the time during which effective drainage persists is proportionately shortened, as extensive adhesion of the coils of intestine soon transforms the peritoneal cavity into a series of isolated cavities, which it is impossible effectually to drain. The most effective drainage is attained by means of a tube inserted into the pelvis. Cigarette drains appear to be the most suitable, but these, in common with other varieties of gauze drains, tend to become occluded and ineffective within a short time.

My practice is to use a combination of cigarette drains and soft rubber tubes. When operating in a case of septic peritonitis due to appendicitis a cigarette drain is put down to the site of the appendix and then a suprapubic opening is made and a split rubber tube, containing a small piece of iodoform gauze, inserted down to Douglas's pouch. In early cases a cigarette drain is passed down from the iliac wound, along the side of the pelvis and into Douglas's pouch, without making a second incision. This method is undoubtedly sufficient in many cases, and with this small amount of drainage there should be less likelihood of troublesome adhesions. In more severe cases, or those in a later stage, in addition to this a cigarette drain is passed from the iliac wound upward toward the liver.

The general rule that drainage tubes should be left in position until secretion ceases, or has at least appreciably diminished, is not applicable to diffuse peritonitis. It is a difficult question to decide how long drainage should be continued in any given case, owing to the fact that purulent secretion persists almost as long as the drain remains *in situ*, indicating a possibility that its presence may contribute to the maintenance of the suppuration. It is advisable that the drainage tubes should be frequently changed, the tube inserted on each successive occasion being of smaller caliber than the one pre-

[1] Deutsch. Ztschr. f. Chir., vol. xxv and xxvi.
[2] British Med. Jour., 1911, ii, 1070.

ceding it. In this way secretion is gradually reduced without mechanical irritation and contraction of the granulating canal is rendered possible without sudden occlusion of its orifice.

Some of the more recent writers are ardent advocates of tamponage and claim that it has greatly improved their results. Grekow uses large loose tampons of loose gauze, made up in the form of a wick, and places two or three of these in the true pelvis, in such a way as to lift the small intestine out of the latter. In addition a tampon is passed along the outer side of the ascending colon up to the liver and another along the outer side of the descending colon up to the spleen. Care must be taken to place no tampons between the coils of intestine and that the rectum is not compressed by the pelvic tampons. A few gauze strips are placed between the abdominal wall and the intestines, and a large, loose gauze compress in the central portion of the wound. This technic applies to late cases, tamponage being less extensive when the peritonitis is less diffuse. In late peritonitis due to cholecystitis or perforation of gastric ulcer it may be necessary, in addition to the tamponage, to drain the true pelvis through an incision in the lower part of the abdomen, vagina or rectum. Drainage appears to continue for at least forty-eight hours after insertion of the tampons, and the irritation produced by them increases secretion and local leukocytosis. It is also possible that they may set up a certain amount of circulatory stasis, and thus partially inhibit the passage of the endotoxins into the blood and facilitate their neutralization.

Sasse[1] also recommends tamponage, varying in extent with the requirements of each individual case, and thinks that a great advantage of the method is the facility with which the tampons can be changed and at the same time the condition of the abdominal cavity ascertained. In his practice he replaces the gauze tampon by a series of rolled tampons, which can be pushed into every cleft and crevice of the peritoneal cavity by means of the plates and retractors which he has devised for the purpose. The tampons consist of loosely rolled mull compresses, surrounded by a single layer of iodoform gauze. They are about as thick as a coil of the ileum, about 30 cm. in length, and can be shortened according to requirements in individual cases. Petraschewskaja[2] has also had good results from mopping and subsequent tamponage in cases of peritonitis due to perforation of gastric or duodenal ulcer. Boljarski[3] uses tampons of dry aseptic gauze in late cases, sometimes partially contracting the wound by means of metal sutures. Jankowski[4] and Wetterstrand[5] report satisfactory results from similar treatment, the former stating that in his experience it affords the best prospect of cure.

[1] Arch. f. klin. Chir., 1914, ciii, 780.
[2] Beiträge z. klin. Chir., 1914, lxxxix, 516.
[3] Beiträge z. klin. Chir., 1914, lxxxix, 511.
[4] Arch. f. klin. Chir., 1914, ciii, 140.
[5] Deutsch. Ztschr. f. Chir., 1913, vol. cxxi,

Objections have been made to tamponage on the ground that adhesions rapidly form and prevent the draining away of the exudate. It certainly seems likely that the tampons do not continue to drain for more than twenty-four hours, but the fact that they become saturated with exudation, containing toxins and bacteria, in the first twelve hours, indicates that, as a rule, secretion is most abundant during this period. Jankowski found that in cases of sudden death from fibrinous aseptic peritonitis, which had been treated by tamponage without flushing, autopsy showed that in twenty-four hours after the insertion of the tampons the fibrinous deposits had disappeared and the abdominal cavity appeared more healthy than before operation. The undoubted advantages of tamponage are the facility which it affords for inspection of the intestines when the tampons are changed, thus rendering a second operation possible if the conditions are such as to render it desirable.

In certain rare cases drainage may be unnecessary, and some have gone so far as to recommend and practise primary closure of the wound in cases in which the peritonitis is not very far advanced and the septic contents of the cavity are not very toxic in character. Among those who are in favor of primary closure of the wound are Bauer[1] and Rotter.[2] Hartmann,[3] Blake,[4] Grekow, Jankowski, Boljarski and Sasse also report good results from it in cases operated upon at a very early stage, that is to say, within forty-eight hours at the latest after the onset of the peritonitis. Bauer, who removes the pus either by flushing or mopping, uses the method almost exclusively in cases in which the pus is entirely free and encapsulation has not occurred. He states that in his experience it has the following advantages:

1. Intestinal peristalsis returns much more rapidly.
2. Attacks of vomiting are much more rare, and soon cease altogether.
3. Convalescence is shortened, and the patient is therefore able to resume his occupation more quickly.

Rotter also has abandoned drainage, with the following exceptions:

1. Cases in which there is a bleeding-point which cannot be arrested.
2. When there is loss of peritoneal substance.
3. When the peritoneum is purulent and necrotic.
4. When there are budding surfaces covered by granulations.

The operators mentioned above practise either flushing or mopping out of the exudation from the peritoneal cavity in cases in which drainage is not employed.

While the advantages of complete closure cannot be denied, in that it facilitates postoperative treatment, it appears to be suitable only to very early cases, the only exception to this rule being in com-

[1] Arch. f. klin. Chir., 1911, xcvi, 938.
[2] Cited by Schiedtmann: Deutsch. med. Wchnschr., 1912, xxxviii, 1637.
[3] Jour. de Chir., October, 1911, p. 437.
[4] Cited by Le Conte: Ann. Surg., 1906, xliii, 231.

paratively late cases complicated by pregnancy. The advocates of primary closure claim that it conduces to the early reëstablishment of intra-abdominal pressure and prevents the development of ventral hernia. In favor of complete closure without drainage it may be said that the adhesions which are produced by the drains, and which are sometimes responsible for the occurrence of intestinal obstruction, are avoided.

Opinions in regard to the importance of intra-abdominal pressure in diffuse peritonitis vary considerably. From the results of experiments on dogs, Jankowski concludes that it is increased in peritonitis and that variations in pressure play an important role in the elimination of toxic material from the peritoneal cavity. He states that they also indicate that in advanced peritonitis the less affected portion of the cavity may, to a certain extent, compensate the function of the more severely involved part.

The Fowler Position.—Postural methods have long been employed in the treatment of peritonitis. In 1897 Clarke recommended that the foot of the bed should be raised about 20 degrees in order to facilitate diaphragmatic resorption, and claimed that this position would effectually prevent postoperative peritonitis. This method has since been generally abandoned, even by Clarke himself, partly owing to the discomfort which it causes to the patient, but chiefly owing to the great risk of producing toxemia by rapid resorption through the diaphragm.

The elevated position of the head and trunk, known as the Fowler position, has now been generally adopted. It has proved very valuable in practice from a clinical point of view, and a study of the statistics shows that it has considerably reduced the mortality of peritonitis. It greatly facilitates drainage, the fluid tending to fall into the pelvis, the serosa of which absorbs less than that of the subdiaphragmatic region, and it also facilitates respiration. Paterson[1] and Maylard[2] are of the opinion that the Fowler position tends to prevent subphrenic and other residual abscesses. In my own experience it has certainly reduced the tendency to subdiaphragmatic abscess. On the other hand Gerster[3] states that since its adoption at the Mount Sinai Hospital, New York, in 1905, subphrenic abscess has been much more common.

While Dr. Bevan[4] recognizes the advantages of the Fowler position, he points out that it is advisable not to use it in an unduly exaggerated form. His practise is to allow the patient to lie flat in bed while the head of the bed is elevated from 18 to 20 inches by two chairs. In order to prevent the patient from sliding down in bed a bolster is placed below the buttocks and fixed to the head of the bed by strips of roller bandage.

[1] British Med. Jour., 1911, p. 1070.
[2] Lancet, 1914, i, 608.
[3] Ann. Surg., 1910, li, 490.
[4] Jour. Am. Med. Assn., 1911, lvi, 1184.

The patient is usually placed in the Fowler position immediately after operation, but many surgeons are now so convinced of its efficacy that they recommend that when patients suffering from any acute abdominal condition are being taken to the hospital they should be placed in the ambulance in a semisitting position, should remain in this position until the operation and after the operation until all danger is past.

In order to facilitate the maintenance of the Fowler position I have, during the last few years, been using a Gatch bed, which I have found of the greatest possible value. It not only ensures the patients being kept in the Fowler position, but they find it so comfortable that after it has been decided that they need no longer be kept in this position, they frequently ask to be allowed to remain on the Gatch bed, as they find it much more comfortable than the prone position and infinitely more comfortable than sitting up with a back rest and a bolster.

Postoperative Treatment.—An essential part of the postoperative treatment of peritonitis is regulation of intestinal function and compensation for loss of body fluids. The method which, up to the present, best fulfils these requirements is that recommended by Murphy, which has been adopted by a large number of surgeons. The chief object of his method of proctoclysis is the prevention of peritoneal resorption. The fluid absorbed by the rectum increases diuresis, assuages thirst and improves the pulse and general condition. Murphy uses a solution of 7 parts each of chloride of sodium and chloride of calcium to 1000 parts of water, at a temperature of about 38° C., and finds that 9 to 10 liters of this solution, entering the rectum in twenty-four hours, can be tolerated without inconvenience to the patient. This method of treatment, together with the Fowler position, are the chief factors in the tremendous improvement in the results obtained in the treatment of diffuse peritonitis. Grekow says that an appreciation of the fact that Murphy's method is based on correct and logical deductions has led to its being adopted as a routine procedure in the treatment of peritonitis at the Obuchow Hospital, Petrograd, where it has been used during the last few years with very satisfactory results.

One of the characteristics of saline solution is its tendency to produce hyperemia, and in this connection it should be remembered that Bier teaches that hyperemia exerts a highly antibacterial influence. Moetzel has also demonstrated that intense hyperemia, with abundant secretion of leukocytes, may be produced by warm saline solution.

In cardiac collapse the intravenous infusion of normal saline, containing a few drops of adrenalin, may be useful, and the same may be said of subcutaneous injections of camphorated oil, ether, caffein or strychnin. If there is persistent tachycardia, digitalis in small doses, or the application of ice on the heart, may be useful. Specific cardiac drugs may be of service, notably digalen. Turpentine stupes

sometimes give relief in cases in which there is marked abdominal distention. Some surgeons, including myself, have had very beneficial results from the use of pituitary extract after operation and find that it increases intra-abdominal pressure and stimulates intestinal peristalsis.

Grekow is a very ardent advocate of the administration of morphin, and goes so far as to say that in his opinion it is not possible to cure severe peritonitis without it. He recommends that it should be given soon after operation if the patient complains of restlessness or pain, and claims that it gives rest and sleep, relieves pain and the spasm of dynamic ileus if present, diminishes thirst and stimulates the heart and pulse. Pantopon has a similar effect and is often well borne by patients who do not tolerate morphin. The majority of surgeons, however, with whom I am in agreement, think that opiates of any kind are contra-indicated, as they tend to increase the already existing toxemia, prevent peristalsis and leukocytosis and therefore increase the tendency to paralytic ileus. In my opinion not more than a single dose of morphin should ever be given or is ever necessary, and this for the purpose of relieving the early pain.

Koch[1] states that in his experience appendicostomy has been much more beneficial in the treatment of peritonitis than continuous proctoclysis, but the latter is so much simpler and the results so good that I very much prefer it.

Vomiting.—My practice is to have the stomach washed out immediately before operation, or at the conclusion of the operation while the patient still remains under the influence of the anesthetic, usually the latter, in all cases of septic peritonitis. If vomiting is persistent after operation lavage of the stomach is practised and repeated until vomiting ceases. The occurrence of acute dilatation of the stomach, a condition which is usually not recognized until too late, and is almost invariably fatal, is thus prevented.

For postoperative vomiting, Westerman[2] recommends continuous siphonage by means of a tube inserted through the nose, fastened by a ribbon to the head and emptying itself at its free extremity into a vessel placed at the side of the bed.

Laxatives should never be administered until after the cessation of projectile vomiting, and it is better to rely upon enemas.

Continuous Current of Oxygen.—Weiss and Sencert[3] practise suprapubic drainage, and in order to facilitate it pass a continuous current of gaseous oxygen through the hypogastric tube. This results in evacuation of the pelvic and peritoneal fluid, and may prevent the formation of adhesions. They have shown, both clinically and experimentally, that the current of oxygen tends to produce hyperemia of the serosa, which materially increases its bactericidal and phagocytic characteristics, arrests the development of the bacteria

[1] British Med. Jour., 1911, p. 1070.
[2] Cited by Koch: Loc. cit.
[3] Jour. de Chir., October, 1911, p. 437.

and neutralizes their toxins. By this method, of which I have so far had no experience, they have recently obtained 4 recoveries out of 5 cases.

Camphorated Oil.—Some writers have recommended that camphorated oil should be injected into the peritoneal cavity after operation, with the object of stimulating peristalsis and preventing the formation of adhesions; but it is questionable as to whether this treatment is of any value.

Bier's Treatment.—Bier recommends the postoperative treatment of peritonitis and other acute abdominal conditions by hot air. He claims that it favors resorption of exudation, induces early peristalsis and thus arrests the formation of adhesions. The patient is placed in the Fowler position on removal from the operating room and a hot air chamber placed over the abdomen and kept for twenty minutes at a temperature of 120°. A second application is given in the evening and a third on the following morning, the latter being followed by a rectal injection of glycerin. The treatment is continued for a varying period in accordance with the severity of the case.

Ochsner's Treatment.—It should be clearly understood that Ochsner's treatment is not intended to replace surgery but merely to tide the patient over to a safer period for the performance of an operation.

The method of treatment recommended by Ochsner aims at increasing the resistance of the patient by building up the general condition, reducing toxemia and increasing the excretion of toxic material. It consists in:

1. No food by the mouth.
2. Absolute rest in the Fowler position, or in the dorsal position if the peritonitis is associated with cholecystitis or gastric ulcer.
3. Infusions of normal saline per rectum; nutrient enemas.
4. Lavage of stomach.
5. Ice or hot applications to the inflamed area.

In my opinion conservative treatment should be reserved exclusively for cases in which, for any reason, it is impossible to operate immediately, such as the impossibility of getting a competent surgeon, the long distance from a hospital or difficulty of transport to a hospital. In addition there are cases in which certain contra-indications render immediate operation inadvisable, such as serious disease of the kidneys, heart or lungs. While a brief course of expectant treatment may be justifiable in peritonitis of cholecystic or gynecological origin, owing to its tendency to localization, it must be remembered that surgical experience indicates that diffuse septic peritonitis is almost invariably fatal without operation and that delay in operation is frequently responsible for the death of the patient.

Treatment by Sera and Vaccines.—As far as I have been able to discover from the literature no beneficial results have yet been reported from these methods of treatment in septic peritonitis.

Complications and Sequelæ.—The more serious conditions which may complicate diffuse septic peritonitis include intestinal obstruc-

tion, subphrenic abscess, pulmonary conditions, such as empyema and pneumonia, secondary abscesses in various situations, fecal fistula and septicemia.

INTESTINAL OBSTRUCTION.—Intestinal obstruction is a very common complication of diffuse peritonitis, and in the fatal cases is the most frequent cause of death. It occurs in three forms: (1) Paralytic ileus; (2) mechanical obstruction; (3) spastic or dynamic ileus.

1. *Paralytic Ileus.*—The paralytic form of obstruction may appear at the outset of an attack of peritonitis, but it is more often met with soon after operation in cases in which peritonitis has already been present for several days. Strictly speaking the condition can scarcely be regarded as obstruction, as there is no obstacle to the passage of the intestinal contents but merely functional incapacity to propel them onward. It is probably due to paralysis of the musculature, owing to inflammation, and to the effect of the toxins produced by the microörganisms upon the nerve endings. After operation and drainage in diffuse peritonitis there is always a possibility of the supervention of paralytic ileus, and measures should therefore be taken to prevent it. Neither food, nor cathartics should be given in any of these cases until there has been a spontaneous evacuation of the bowels.

Two precautions which prevent this form of obstruction in many cases should be considered at this point although they have been mentioned elsewhere.

(*a*) The repeated use of gastric lavage with water at 105° F. will remove all decomposing intestinal contents which will regurgitate from the small intestine into the stomach together with the gas which causes an overdistention of the intestines. It also improves the blood supply of the stomach and the intestines by the direct application of heat.

(*b*) In cases in which the small intestines are greatly distended with gas and fluid feces the use of Monk's tube will usually restore the intestinal walls to an approximately normal condition. A glass tube 50 cm. long and 2 cm. in diameter is attached to a rubber tube twice this length. A portion of the distended intestine is held between the fingers and thumb of both hands of an assistant so as to render 15 cm. free from its contents. A silk suture is then applied which can be tightened after the glass tube has been inserted into a slit on the convex surface of the intestine in order to prevent leakage during the necessary manipulations. The tube is then carried into the small intestine not by pushing it in but by folding the intestine over the end of the glass tube as one pushes the finger of a glove on one's finger. When the intestine in one direction has been emptied the tube is turned in the other direction. In this manner the entire gut can be emptied. A few sutures will close the opening.

2. *Mechanical Obstruction.*—When the bowels have moved after operation there is no longer any fear of paralytic ileus. The danger then is from mechanical obstruction, which may occur when adhesions

have formed, usually at the end of a week or ten days. The site of obstruction is most often in the lower part of the ileum.

3. *Spastic or Dynamic Ileus.*—Fromme[1] gives the name of dynamic ileus to a spastic contraction and paralysis of the intestine which produces obstruction without mechanical occlusion of its lumen. Spastic ileus is an extremely rare condition, and its existence has been denied by some writers, but Fromme has been able to find reports of 20 cases in literature, in which the diagnosis was confirmed either by exploratory laparotomy or on section. He himself reports 2 further cases, in both of which laparotomy was done on the assumption of the presence of mechanical ileus. On opening the abdomen, however, no mechanical obstruction was discovered, but the intestinal canal was seen to be in a state of spasmodic contraction, the lumen being considerably reduced in size.

The causes which are influential in the setting up of spastic ileus are still more or less obscure, but Fromme suggests that the cases include those due to external or internal irritation of the intestine, those due to hysteria, and others in which the etiology is uncertain.

In peritonitis complicated by ileus it is now generally agreed that the ileus and not the peritonitis is the chief factor in the fatal result, and a consideration of the manner in which intestinal obstruction endangers life is therefore of practical importance. The following causes of death have been suggested: (1) Its mechanical results, which include compression of the heart in an upward direction, compression of the lungs, and interference with circulation in the abdominal and thoracic cavities; (2) general toxemia, due to resorption of bacteria and toxins from the intestinal contents; (3) a pathological change in the sympathetic nervous system; (4) depletion of body fluids.

As to the deleterious effects of mechanical compression there can be no difference of opinion. On the other hand the paramount importance of toxemia has been much discussed in recent publications and experimental results in this connection have not been conclusive. McLean[2] has carried out a series of experiments in dogs, with the object of determining this question, and states that the results do not indicate that death is due to toxemia. Bacteria could not be demonstrated in the blood or by the injection of the peritoneal or gastric contents into guinea-pigs. Braun[3] had similar results from the injection of toxic doses of strychnine, the animals dying from the ileus and not from strychnine poisoning. Both he and McLean found that absorption from the intestine is reduced in ileus, and conclude that death is not due to toxemia, absorption of bacteria or of their toxins, or of abnormal physiological secretion.

On the other hand Stone and Whipple report diametrically opposite experimental results, and state that in dogs the whole course of the postoperative disturbances suggests toxemia. They believe they

[1] Deutsch. med. Wchnschr., 1914, xl, 1010.
[2] Ann. Surg., 1914, lix, 407.
[3] Ztschr. f. Chir., 1908, xcvi, 544.

have found the cause of death in a toxin formed by the mucosa of the occluded loops of intestine, which on injection into normal dogs produces a reaction resembling that observed in those experimented upon. They have succeeded, by the injection of sublethal amounts of this toxin, in immunizing dogs against full doses.

In addition McLean has carried out experiments on dogs in order to ascertain the effect of removal of body fluids. In animals which died from experimental ileus there was invariably marked loss of weight, the weight lost in a period of sixty-seven hours averaging two pounds. Such a loss as this must certainly affect blood-pressure. Hartwell and Hoguet[1] have shown experimentally that dogs die when the administration of saline solution is given up, autopsy indicating that they might have lived considerably longer had it been continued.

When the obstruction is due to a slight or localized peritonitis it may be relieved by saline cathartics, enemata and drugs which stimulate peristalsis. Strychnine, atropine, physostigmine and pituitary extract have been recommended, the most effectual of these being physostigmine and pituitrin. I have had very good results from the administration of $\frac{1}{50}$ grain of salicylate of physostigmine every four hours, and in certain cases pituitrin, given in doses of 1 c.c. every four hours, has seemed to be even more effective. While there is no doubt that pituitrin has in suitable cases a powerful effect in stimulating peristalsis, it should always be borne in mind that it is a dangerous drug to use in certain cardiovascular conditions. Calomel in small doses, followed by magnesium sulphate, should also be given, but never in cases in which there is any danger of spreading the infection by the resulting peristalsis, and following this enemata are usually of the greatest value. A so-called 1, 2, 3 enema, *i. e.*, 1 ounce of glycerin, 2 ounces of magnesium sulphate, 3 ounces of water, may be given every two or three hours, or this enema and a simple enema to which is added from $\frac{1}{2}$ to 1 ounce of turpentine may be given alternately.

In cases of great abdominal distention benefit will occasionally be obtained from the use of hot fomentations, with a little sprinkling of turpentine. It is quite possible that the resulting hyperemia may influence the circulation in the intestinal coils, and thus favor peristalsis.

If, however, at the time of operation the coils of intestine are seen to be distended and thinned it is useless and dangerous to employ medical measures. Cecostomy or appendicostomy may be of service, but in severe and advanced cases enterostomy should be performed. Volterrani has reported 8 cases, 6 of which were cured by enterostomy. Grekow, of the Obuchow Hospital, Petrograd, has performed primary enterostomy at the same time as the operation for peritonitis in 14 very advanced cases of paralytic ileus, with 6 cures. He also reports 1 case of diffuse peritonitis and mechanical obstruction which recovered after similar treatment. I can also report 4 cases of pri-

[1] Experimental Intestinal Obstruction.

mary enterostomy with recovery. McLean has reported 3 cases of appendicular peritonitis in which he anticipated postoperative ileus by performing ileostomy at the primary operation. All 3 cases were practically moribund and all recovered. He recommends primary ileostomy in all severe cases of peritonitis, and believes that since its adoption he has been able, by a combination of this operation and the free administration of saline solution, to save 65 per cent. of cases of severe ileus, which would otherwise have terminated fatally. In exceptionally severe cases it may be necessary to make multiple fistulæ. It does not seem advisable to establish intestinal fistulæ, excepting as a last resource, in view of the unpleasant nature of the complication and the fact that fistulæ of the small intestine and cecum have a deleterious effect upon nutrition. In apparently hopeless cases I have made multiple punctures of the intestines by means of a fine cannula, the openings afterward being closed. In 2 cases at least this procedure has saved the lives of the patients and in the other cases it has added very considerably to their comfort.

In the more severe cases, after removal of the primary cause of the peritonitis, I have been in the habit of having a rectal tube passed while the abdomen is open, so that, with my hand in the abdomen, I can manipulate it through the sigmoid and up into the descending colon. This tube is fastened near the anus by a silkworm-gut suture through the skin. This renders it possible to give enemas higher up than can be done in the ordinary way, and consequently they are more likely to be effectual. I am convinced that this method has been of material service in cases in which there was reason to fear the development of paralytic ileus.

After operation for diffuse septic peritonitis I should like to emphasize the importance of careful watching for the early symptoms of mechanical obstruction, which, as previously mentioned, usually appear at the end of a week to ten days and to urge immediate operation. If at the end of a few days or a week the patient suffers from nausea and vomiting, and if a purgative or enema is not effective, it is inadvisable to delay more than a few hours before resorting to surgical measures. If much time is wasted in giving enemas the patient will become so weak that even though the operation is performed later and the obstruction relieved, recovery will not follow. Since keeping a close watch for the early symptoms of mechanical obstruction, and making it a rule to operate at once, I have not lost a single case from this cause, whereas a few years ago several lives were lost, owing to the fact that operation was delayed in the forlorn hope of a result from purgatives and enemata. Several patients operated upon in the country in whom this complication appeared at the end of a week or ten days have lost their lives because a surgeon was not called to give the necessary relief by a second operation.

In the experience of the editor postoperative ileus has disappeared entirely since introducing the rule of covering all raw surfaces in the abdominal cavity with peritoneum and using gastric lavage immedi-

ately in case of postoperative gaseous distention, giving neither food nor cathartics of any kind by mouth until there has been a spontaneous evacuation of the bowels in any case in which there are the slightest symptoms of impending postoperative ileus and using Murphy's proctoclysis and exclusive rectal feeding in all such cases.

Subphrenic Abscess and Pulmonary Complications.—In diffuse septic peritonitis, with abundant seropurulent effusion, the latter may, either by direct extension or extension through the lymphatics, form a subphrenic abscess. The onset of the symptoms indicating the presence of this complication may be sudden or gradual. They consist of elevation of temperature, possibly associated with rigors, vomiting, rigidity and pain, the latter often being increased on respiration. Pressure over the lower ribs on the right side will elicit tenderness, and there will be some muscular rigidity immediately below this. There is increased liver dulness, and later the liver becomes displaced downward, with marked bulging of the lower right ribs. The treatment consists of incision and drainage.

Extension of a subphrenic abscess along the under surface of the diaphragm often leads to secondary infection of the pleura, resulting in effusion of serum or pus into the base of the pleural cavity, and the formation of a basal empyema. In total empyema the affected side of the thorax does not move on respiration, and there may be bulging of the intercostal spaces, with dulness on percussion over the area involved. Loss of vocal fremitus is a significant sign. There is usually fever and dyspnea, marked leukocytosis and displacement of the heart and other viscera. The diagnosis can usually be made from the physical signs, confirmed, if necessary, by puncture. The organism has a considerable influence upon the prognosis of an empyema, which is more grave in the presence of pyogenic cocci than of pneumococci. In the latter case the condition is sometimes relieved by aspiration alone, but in the former drainage and resection of a rib are required.

In some cases which have recently come under my own observation a subphrenic abscess developed and extended to the pleura on the right side, and was followed by the development of a right empyema.

With the object of preventing pulmonary complications, more especially pneumonia, which is often the cause of death, pulmonary gymnastics are sometimes practised after operation, and injections of camphor given for the first eight days. Early treatment by massage of the lower extremities helps to prevent thrombophlebitis. The same end is accomplished by having the patients move their lower limbs freely after abdominal operations.

Statistics.—The extraordinary variations in the results reported by different writers, the mortality varying between 3 and 80 per cent., or even more, are apparently chiefly dependent upon the differences which have been previously referred to in the application of the term *diffuse peritonitis*, and upon the fact that in some cases the severity of the symptoms does not correspond to the extent of inflammation.

In not a few cases in which the classical symptom-complex is practically absent the whole of the peritoneal cavity is found to be involved on opening the abdomen. It is also obvious, from a study of the statistics, that in some districts, or in the practice of a particular surgeon, opportunities of operating at an early stage are more frequent, and this naturally tends to improve the results. This may be partially due to the circumstances of the people in the neighborhood, to financial conditions and also, to a certain extent, to the fact that the general practitioners are favorably impressed in regard to the value of surgery in the treatment of diffuse peritonitis.

In 1890 Stühler, of Strasburg, reported 78 cases of drainage of the peritoneum for peritonitis, with 50 cures and 28 deaths. In 1892 Körte[1] reported 19 cases operated upon, with 6 recoveries and 13 deaths (68.5 per cent.), and in 1897 he collected 133 cases from literature, with 51 recoveries and 82 deaths (61.8 per cent.). From the literature appearing between 1885 and 1893 Mikulicz collected 35 cases, with a mortality of 97 per cent., and 68 cases from that published between 1894 and 1896, the mortality being reduced to 54 per cent.

The Fowler position was first recommended in 1904 by George and Russell Fowler,[2] who reported 100 cases operated upon between 1901 and 1904, with 67 recoveries and 33 deaths (33 per cent.).

Murphy's technic, which is now generally adopted and which has given excellent results, consists in rapid removal of the cause of the peritonitis, drainage of the lower part of the pelvis, the Fowler position and the prevention of peristalsis by withholding food and liquids by the mouth. The treatment recommended by Noetzel[3] in 1905 closely approximates to this, but he recommends lavage of the stomach as a routine procedure, and does not withhold food and liquids by the mouth. Dépage,[4] of Brussels, at the meeting of the French Congress of Surgeons in 1911, stated that since 1906, at which time he adopted a method analogous to that of Murphy, his mortality had diminished from 40 to 9 per cent. At the meeting of the American Surgical Association in 1908, Dr. Murphy reported 50 cases of peritonitis, chiefly due to the appendix, with only 2 deaths. Most of these cases were operated upon in from twenty-two to thirty hours after the onset of symptoms.

Boljarski, of the Obuchow Hospital, Petrograd, states that the mortality of diffuse peritonitis in this hospital has been reduced from 79.7 per cent. in 1903 to 32.2 per cent. at the end of 1912. This improvement applies more especially to the period between 1909 and 1912, since which they have based their treatment upon the principle of early operation. Grekow also reports cases which have come under his observation at the Obuchow Hospital. In 101 cases of appendicular peritonitis there were 59 cures and 42 deaths (41.5 per cent.). Thirteen of the cases were operated upon within twenty-

[1] Arch. f. klin. Chir., 1892, xliv, 612.
[2] Med. News, May 28, 1904.
[3] Beiträge z. klin. Chir., 1905.
[4] Jour. de Chir., October, 1911, p. 437.

four hours, with 3 deaths (23 per cent.); 29 within forty-eight hours, with 2 deaths (6 per cent.); 15 on the third day, with 3 deaths (20 per cent.); 25 on the fourth or fifth day with 18 deaths (72 per cent.); 12 on the sixth or seventh day, with 9 deaths (75 per cent.); 7 on the eighth to the twenty-first day, with 6 deaths (85 per cent.). Sasse reports 141 cases of appendicular peritonitis which occurred in the Frankfort Clinic between 1909 and 1913, with 15 deaths (10.6 per cent.).

In 1910 Dr. Gerster reported 609 cases of peritonitis, operated upon at the Mount Sinai Hospital between 1899 and 1908, 461 being due to appendicitis. The patients were, as a rule, operated upon within an hour after admission to the hospital, and in the appendicular cases the mortality has been gradually reduced from 79 per cent. in 1899 to 14 per cent. in 1908. He employs Murphy's method of treatment.

At the Congress of French Surgeons held in Paris in 1911, Hartmann[1] reported 56 cases operated upon at the Bichât Hospital between 1908 and 1911, 46 being of appendicular origin. Of the appendicular cases 15 were operated upon during the first thirty-six hours, with no mortality; 10 during the first forty-eight hours, with a mortality of 10 per cent.; 13 in from two to four days, with a mortality of 38.5 per cent.; 8 after the fourth day, with a mortality of 100 per cent. Three cases of gastric or duodenal perforation were operated upon in from six to twelve hours after the onset of symptoms, with recovery in every case. The remaining 7 cases, 2 due to intestinal perforation, 3 to disease of the uterus or adnexa, 1 to acute enteritis of the large intestine and 1 to perforation of the biliary bladder, did not come under observation for some considerable time after the onset of symptoms, and all died.

As regards ulcer of the stomach and duodenum, Terrier and Hartmann report 53 cases operated upon within twelve hours, with 16 deaths (30 per cent.); 38 in from twelve to twenty-four hours, with 22 deaths (58 per cent.); 29 in from twenty-four to forty-eight hours, with 22 deaths (76 per cent.). Petraschewskaja reports 32 cases of ulcer of the stomach and duodenum operated upon previous to 1910, with 2 cures, and 21 cases, with 8 cures, operated upon during the last three and a half years. Of these 21 cases 11 were operated upon during the first twelve hours, with 6 deaths (53.3 per cent.); the others in from three to nine days after perforation, with a mortality of 100 per cent. Rowntree[2] states that in his cases of gastric perforation, with one exception, the patients who died were operated upon more than twenty-four hours after perforation. The exception was a man, aged fifty years, in whom perforation had occurred two weeks before admission to the hospital. Several incisions were made, with the object of affording free drainage, and he subsequently made a good recovery.

Siegel[3] states that in peritonitis due to abdominal wounds involving the digestive tract operation within the first four hours has a mortality

[1] Jour. de Chir., October, 1911, p. 437.
[2] Ann. Surg., 1914, lix, 587.
[3] Cited by Hartmann.

of 15 per cent., within five to eight hours 44 per cent., within nine to twelve hours 66.6 per cent. and after twelve hours 70 per cent. In 1911 Tschisstosserdoff[1] published 52 cases of traumatic rupture of the intestine, which came under his observation at the Obuchow Hospital between 1897 and 1910, 47 of which were operated upon, with 40 deaths (88.4 per cent.). Of 10 operated on in the first six hours, 6 died (60 per cent.); of 25 in the first twenty-four hours, 21 died (88 per cent.) and 12 after the first twenty-four hours, all died. Grekow reports 13 cases operated in from one to four hours, with 5 deaths (36.7 per cent.).

Beavis and Souttar state that their experience in Belgium indicated that in cases of peritonitis from bullet and shrapnel wounds the prognosis was fairly good if operation was performed within six hours, but that very few recovered after a delay of more than twelve hours.

As regards the effect of methods of treatment upon mortality, the results of experience indicate that flushing out of the peritoneal cavity increases resorption of bacteria and their products and tends to induce shock. In 19 cases in which Grekow flushed out the cavity the post-mortem appearances indicates that death in the 15 fatal cases was due to sepsis. Of 10 cases of traumatic rupture of the intestine, operated upon during the first six hours, 4 treated by flushing died while of 6 treated by the dry method 4 recovered. On the other hand, in 28 cases operated upon in from six to twenty-four hours, of 5 treated by flushing 1 recovered while of 23 in which the dry method was employed 2 recovered. Grekow, therefore, concludes that the dry method is the most suitable for early and flushing for late cases of peritonitis.

The results confirm the assumption that early intervention is the most important factor in success, and indicates that the *fate of the patient is therefore dependent upon the early diagnosis made by the physician, and upon the prompt removal of the primary cause of the peritonitis.*

Between 1907 and 1912, 282 cases of appendicular peritonitis came under my own observation, with 45 deaths (15.1 per cent.). The mortality has diminished from 27.2 per cent. in 1907 to 9.2 per cent. in 1912. Since this latter date the results which have been obtained have gradually improved, and now in my private practice the mortality rate is not more than 5 per cent.

Conclusions.—1. That early operation is imperative in all cases of acute appendicitis, and that by it practically all of the cases of diffuse peritonitis dependent upon the appendix would be avoided.

2. That the operation should be rapidly performed, with as little manipulation of the intestines as possible.

3. That proctoclysis and the Fowler position are of great value.

4. That a second operation should be performed immediately symptoms of mechanical obstruction appear.

5. That gastric lavage be employed immediately upon the appearance of postoperative nausea or vomiting or gaseous distention.

[1] Beiträge z. klin. Chir., 1912, lxxix, 70.

SURGERY OF THE RECTUM AND ANUS.

By CARL B. DAVIS, M.D.

ANATOMY OF THE RECTUM AND ANUS.

There are various landmarks used in designating the limits of the rectum. A convenient definition is that the rectum consists of the portion of the large gut extending from the level at which the peritoneum leaves the large intestine to the beginning of the anal canal.

The average length of the rectum is five or six inches, varying with the sex and the individual. The diameter is approximately one inch in the upper portion and about three inches in the widest portion of the rectal ampulla.

The sacculations of the large intestine are represented in the rectum by three definite sacculations formed by the bending inward of all coats of the bowel. These transverse rectal ridges are known as the valves of Houston. Numerous operative procedures are suggested for destroying these ridges in the treatment of constipation, while in reality the source of the disturbance is most frequently in the colon.

The anal canal begins at the end of the rectum at the point where the bowel perforates the pelvic diaphragm and extends to the external anal orifice. The length of the canal is about one inch. The direction of this portion of the bowel is upward and forward entering the ampulla at about a right angle. This relation should be kept in mind when inserting a proctoscope or other instrument.

The rectum has a small triangular peritoneal area on the anterior surface of the proximal end. There are two muscular coats, longitudinal and circular, and a mucous membrane of cylindrical cells. The lining of the anal canal is a flat or squamous-cell membrane. The difference in cell type is due to the difference in origin of the two structures: the rectum grows downward from the hind gut while the anal canal develops from a protrusion inward of the ectoderm—a structure known as the proctoderm.

The junction between these two types of cells is not an even white line as is sometimes described, but is an irregular union marked by numerous projections upward of skin sometimes attached by their bases and edges with a free margin above forming the so-called valves of Morgagni. At times these projections are free on the edges merely forming small, white papillæ. Above these pouches the mucosa is thrown into a number of folds, the columns of Morgagni.

The rectum and anus are attached to the pelvis by the levator ani muscle, the superficial and deep sphincters, by ligaments and by various layers of fascia.

Blood Supply.—The blood supply of the rectum and anus comes from the superior, middle and inferior hemorrhoidal arteries. The superior hemorrhoidal artery arises from the inferior mesenteric artery and drops in an almost straight line to the posterior wall of the rectum, dividing into right and left branches and again into smaller branches which surround the bowel. The superior hemorrhoidal artery anasto-

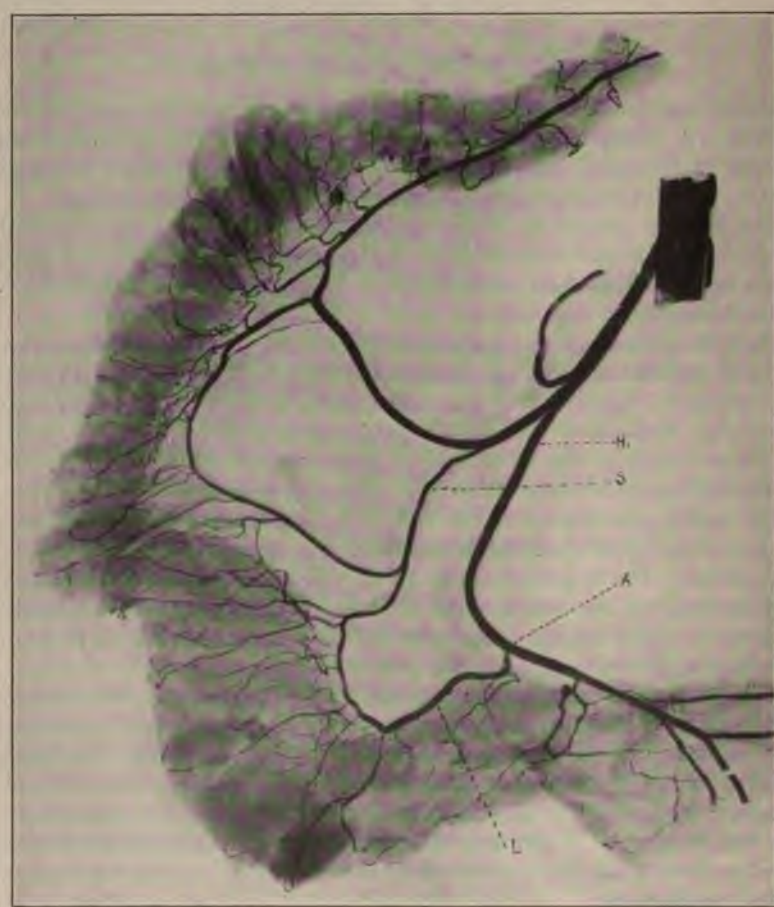


FIG. 85.—Injected specimen, showing the aortic, inferior mesenteric, sigmoidal, superior hemorrhoidal arteries and anastomotic loop. *H*, superior hemorrhoidal arteries; *S*, sigmoidal artery; *L*, anastomotic loop; *A*, critical point below which ligature may not be applied.

moses with the middle hemorrhoidal artery which is a branch of the internal iliac artery. The middle hemorrhoidal artery passes from the side of the pelvis to the lateral aspect of the rectum. The inferior hemorrhoidal artery arises from the internal pudic artery and passes across the ischiorectal space and is distributed to the structures of the anal canal and also anastomoses with the middle hemorrhoidal artery.

It has occasionally been noted that operation by the sacral route upon carcinoma situated high in the rectum has been followed by gangrene of the bowel which has been freed to permit of the establishment of a perineal or sacral anus. Hartman has shown that the safe point for ligation of the superior hemorrhoidal artery is proximal to the junction of the lowest anastomotic loop from the sigmoidal artery. After ligation at the point described the blood passes from the sigmoidal artery through the anastomotic loop and into the rectal vascular supply below the level of the ligature. Ligation of the superior hemorrhoidal artery distal to the anastomotic loop results in almost complete cutting off of the blood current to the upper rectum and gangrene follows.

FIG. 86.—Arrows indicate the lymphatic drainage in the rectum and anal canal. The ascending current passes upward to the glands in the mesorectum. The descending current passes across the perineum and into the inguinal lymph glands.

Variation in the recto-sigmoidal anastomosis is common. The anastomosis is found at varying distances from the bowel and at varying heights; on an average it is about one inch below the level of the promontory. The rule at operation of clamping the vessels as far back from the rectum as possible results in missing the loop where it lies close to the bowel.

Lymphatics.—The lymphatics of the rectum and anus follow the embryological division of tissues. The anal canal developing from the proctoderm has a lymphatic system that drains downward from the muco-cutaneous line, passes across the perineum and terminates in the inguinal lymph glands. The lymphatics of the rectum pass upward from the muco-cutaneous line and drain into the glands along the posterior wall of the rectum and finally into the aortic glands.

Nerves.—The nerves of the rectum are similar to the sympathetic system of plexuses of the rest of the bowel. Nerves of sensation are absent. The anal canal is largely supplied with sensory nerves. The levator ani and sphincter muscles are supplied by branches from the sacral plexus, especially the third nerve.

MALFORMATIONS OF THE RECTUM.

Atresia.—Among the more common malformations of the rectum is atresia, varying from complete absence of the structures to a mere narrowing of the anal outlet. The bowel may terminate in the bladder or urethra. In the male the fecal outlet may be between the under surface of the glans and foreskin, at the base of the penis, through the scrotum or in the perineum. In the female the fecal outlet may be at the vulva or in any portion of the posterior vaginal wall, usually in the posterior fornix. The origin of these abnormalities is readily explicable on an embryological basis.

Symptoms.—The symptoms vary according to whether the bowel is completely closed or if a fistulous outlet is present.

In the former case symptoms of ileus develop early after birth. If unoperated upon the child dies in a few days from collapse or peritonitis due to rupture of the bowel. At times a narrow fistulous tract exists in place of the normal structures. This can be dilated and the patient carried over the crisis.

The condition in which the fistula ends in the vagina or vulva, may persist into adult years without becoming dangerous to life. The perforation of the recto-anal diaphragm may be only partial, resulting in a congenital stricture. This could be detected readily by a proctoscope and incised to proper caliber. Vesical and urethral fistulæ are more serious in that cystitis and ascending infections result with secondary pyelitis.

Treatment.—Where possible fistulous tracts are to be dilated for temporary or permanent passages, as the case may be, if the examining finger or proctoscope shows a bulging of the hind gut or rectum into the perineum or anal orifice, it is well to puncture the intervening tissue and establish a fistulous tract which later may be handled as seems best indicated. Where no fistula or bulging is present it is necessary to do a colostomy, preferably in the sigmoid colon. At operation one may determine by abdominal exploration the extent of the defect. Where an effort is made to establish a passage through the perineum, if no anal orifice is present, it is well to attempt to pass through the

center of the anal sphincters if they are present. If at operation no rectum is found the colostomy should be so established that a redundant loop is present to protect the individual against too frequent emptying of the bowel. Later a loop of the ileum may be transplanted to form a new anal canal.

FOREIGN BODIES IN THE RECTUM.

Foreign bodies in the rectum may lodge while passing in the fecal current, or may be introduced from without. Fish bones or inorganic objects swallowed by children or the insane may lodge in the walls of the ampulla. Articles may be hidden in the ampulla. Various things are introduced into the bowel by sexual perverts. Insane patients not infrequently crowd very large objects in the rectum. Fecal concretions sometimes of large size accumulate in the ampulla.

Symptoms.—The symptoms may be those of an obstruction of the fecal current or may be due to the traumatism and infection of the bowel wall following the impinging or lodging of some part of the body in the wall of the gut.

Digital examination or visual inspection by means of a speculum or proctoscope is usually sufficient to determine the difficulty.

Treatment.—In treatment of these lesions it is not wise to use cathartics as the increased peristaltic pressure may force the foreign body deeper into the tissues. An oil enema is frequently sufficient to cause the passage of the object. General anesthesia, dilatation of the sphincter and instrumental delivery of the foreign body is necessary in some cases. Unnecessary force, of course, must be avoided.

TRAUMA OF THE RECTUM.

Trauma of the rectum varies from slight excoriations, due to the passing of small foreign articles, to the enormous destruction seen in gunshot wounds. A history of the accident is suggestive of the extent of the damage. Hemorrhage may be present, but not immediately visible as the blood may pass upward into the sigmoid or descending colon. Where the urinary tract is involved or where extensive injury to the surrounding tissue is present, it is well to do a colostomy diverting the fecal current until the associated defect and infection have cleared up.

PRURITUS ANI.

Pruritus ani may result from hemorrhoids, rectal polyps, vaginal or uterine disease, constitutional disease or the eating of certain foods. Worms in children often cause intense itching. Treatment should be directed toward the primary cause and in local treatment by means of salves and lotions. Roentgen ray therapy has been useful. A circular incision about the anus through the skin with slight displacement of the surfaces and suture has given relief in obstinate cases.

INFLAMMATION OF THE RECTUM.

Acute catarrhal conditions of the rectum are not primarily surgical lesions. Syphilis and tuberculosis become surgical lesions when extensive ulceration of strictures develop.

Anal Fissure.—Anal fissure is an ulcer in the anal mucosa, characterized by intense pain and spasm of the sphincter, especially after a bowel movement. Following a stool there are frequently a few drops of blood. At times the pain radiates into the buttocks or pelvis and rarely results in acute retention of urine. Fissure is frequently associated with hemorrhoids, polyps and stricture. A thorough digital examination is made with great gentleness or, if the patient is too sensitive, under anesthesia—preferably nitrous oxide.

Treatment.—Treatment consists in control of bowel movements by oil enemata, cleanliness of the anal orifice and local applications of a weak solution of silver nitrate. Under local or general anesthesia the sphincter is stretched and the fissure broken open or incised with a knife. The defect is then packed with gauze for several days.

Perirectal Infection and Ischiorectal Abscess.—Perirectal infection and ischiorectal abscess are common lesions. They are due usually to a break in the rectal mucosa, resulting in an ulceration and escape of the infection into the surrounding tissues. Frequently there is a direct connection between the infected area and the lumen of the bowel. These infections at times spread as high as the peritoneum and extend downward into the perineum and as far as the trochanteric region of the thighs. Such conditions are accompanied by a rise of temperature, pain and tenderness, and sooner or later a tumor presents itself. If neglected these cases at times show symptoms of severe sepsis.

Treatment.—Treatment should be incision as early as possible with the incision carried up to the defect in the rectal wall. The sphincter should be preserved if possible.

Fistula Ani.—Fistula ani results when a perirectal infection finally perforates the skin. Fistula is often associated with chronic disease, such as diabetes or tuberculosis. Fistula is more frequent in men than women. The symptoms vary from a slight uneasiness to intense pain with a discharge of pus, gas and feces. At times the rectal or proximal end of the fistula heals and a discharge of gas and feces is not present.

Diagnosis.—Diagnosis is readily made by passing a small blunt probe into the tract. Not infrequently this can be carried into the lumen of the bowel. A finger in the bowel pressing against the tract will cause a few drops of pus to escape. The examining finger usually comes in contact with an indurated papilla or strand in the mucosa. Within this induration is the proximal opening of the fistula.

Treatment.—Treatment is surgical. A grooved director is passed from the external opening along the fistulous tract and into the bowel if an internal opening is present. If no opening is found carry the sound to the highest point of the disease and then break into the bowel. The intervening tissue between the director and the anal orifice is cut

through. The exposed fistula is then thoroughly curetted to remove all the granulation tissue which lined the tract and the wound is packed with gauze. The gauze is renewed as often as it will hold its position. In this way the wound heals from its depth first. If packing is omitted the fistula will frequently reform in convalescence due to healing together of the incision in its outer surfaces.

Excision of the fistula with primary suture has been used somewhat. Its success depends upon complete eradication of the infected tissue and fistulous lining of granulation tissue.

Secondary suture of the sphincter is done where the muscle is sacrificed in exposing extensive fistulæ.

STRICTURE OF THE ANUS AND RECTUM.

Stricture of the Anus.—Stricture of the anus occurs at the anal orifice and in the anal canal. This may be due to a congenital failure of development, or from ulceration, traumatisms, or surgical procedures, such as the Whitehead operation, or a too vigorous use of the cautery. The patient experiences great difficulty in defecation. The stools are narrower than normal. Visual or digital examination reveals the condition. Gradual dilatation gives temporary relief. The stricture usually recurs after this method of treatment. Various plastic procedures mobilizing the skin and lining of the anal canal are used to overcome stricture at the orifice.

Stricture of the Rectum.—Stricture of the rectum is more frequent than stricture of the anal canal and is more frequent in women than in men. Gonorrhea in the female is more readily communicated to the rectum than in the male. A majority of the women with benign stricture of the rectum give a history suggestive of a former Neisserian, genital infection. Stricture follows perirectal disease in the pelvis; injury to the rectal mucosa from enemata that were too hot and from direct trauma. Syphilis and tuberculosis are always listed as causes of stricture, but are not so common as was formerly thought. Cancer of the rectum is the most common cause of rectal stricture, and will be discussed later, page 327. Benign stricture of the bowel may persist for years and at times results in an ascending ulceration with a following cicatrization giving rise to a body of scar tissue, several inches long with a lead-pencil-like lumen traversing its center.

Symptoms.—Stricture is accompanied by symptoms of chronic catarrh, painful stools, irregular constipation and diarrhea, varying with the consistency of the feces, and sooner or later evidence of obstruction. The patient soon learns that distress is avoided by the use of saline laxatives or anything that results in liquid stools. The disease tends to become progressive.

Treatment.—I have seen a well developed stricture disappear under medical treatment and dilatation. Gradual dilatation of the stricture with bougies gives temporary relief; and the patient learning the use of the bougies is able to obtain considerable comfort.

The operative treatment varies with the type and location of the stenosis. Formerly efforts were made at incising the stricture from within, rectotomia. This has proved unsatisfactory. Various forms of rectoplasty through the posterior rectal wall have been devised. Longitudinal incision of the stricture and transverse suture are the basis of most methods. Resection of the diseased area has been employed, but is dangerous in that sphincter control is frequently destroyed by severing the sacral nerves. Troublesome and persistent fecal fistulæ in the operative scar are not infrequent.

An inguinal anus or colostomy is frequently employed in conjunction with the above method of treatment to divert temporarily the fecal current from the operative region. The colostomy should be formed in such a manner that the intervening spur, between the afferent and efferent loops of gut, may be grasped in a clamp and destroyed when the operative field has returned to normal.

There is no single operative procedure indicated. When conditions permit—a stricture of small extent—some form of plastic work is to be tried, but where an extensive cicatrization and induration has taken place it is better to do a complete resection with a colostomy. In some cases the sigmoid is cut across and the proximal end brought through the abdominal wall, the distal end being closed in and dropped into the pelvis. Within a few days after the fecal stream has been turned away from the ulcerating and stenosed area, the infection subsides rapidly and the blind segment gives but little distress. The mortality rate is lowered greatly by this simplification of technic.

HEMORRHOIDS.

Hemorrhoids are protruding masses in the anal region due to the dilatation and overgrowth of the hemorrhoidal venous plexus. They are known as external and internal, according to their location in the anal canal. The external type are seen to be bluish-white masses in the skin surrounding the anus, varying in size from that of a pea to the size of a golf ball. They may be present for years and the patient is conscious merely of slight itching or pain. At times they become infected, the skin thins out and repeated hemorrhages result, or hemorrhage takes place within the hemorrhoidal mass and thrombosis results.

Internal hemorrhoids are readily palpated by an examining finger and are seen when the canal is dilated with a speculum. The internal type bleeds very readily, which is frequently the first indication of their presence. The blood is passed on the surface of the stool and at times at the end of defecation. The amount of blood is small, as a rule, but may be of such proportions as to weaken the patient. The hemorrhage may occur at each defecation, or may occur at intervals of months. Hemorrhoidal bleeding is worse with a firm, constipated bowel movement. The hemorrhage from a cancer of the rectum is associated with

a morning diarrhea. The loss of blood can best be estimated when the patient strains over an open vessel. The prolapsing mass at times shows a pulsating stream as the patient presses down with no escape of bowel content.

Hemorrhoids are often associated with cancer of the rectum. The differential diagnosis is usually made by inserting the index finger into the bowel or better on visual examination of the bowel by means of a proctoscope to the level of the recto-sigmoidal junction.

Hemorrhoids are often associated with other sources of interference with the portal circulation, cirrhosis of the liver being a common complication. Patients suffering with splenic anemia often have hemorrhages from the rectal mucosa.

A thorough physical examination and careful history should be taken in every case of hemorrhoids so that the patient may be spared an unnecessary operation if possible.

Treatment.—Treatment is palliative and surgical. Under the former might be mentioned pessaries, lotions, ointments and control of the constipation. Hot boric dressings are helpful in the stage where an inflamed sensitive protrusion of a hemorrhoidal mass has occurred.

Surgical treatment is indicated in repeated severe hemorrhages, in repeated prolapse of the hemorrhoids and pain at each defecation because of the inflamed condition of the relaxed mucosa. The methods employed vary from the injection of a few drops of a mixture of 1 part of carbolic acid to 5 parts of glycerine, into each hemorrhoid, to the Whitehead procedure where the entire circumference of the mucosa is dissected loose, pulled down, resected and sutured to the skin margin. Another method in frequent use is to pull down each hemorrhoidal mass, incise the mucosa at its base and apply a silk ligature about the base in the defect of the mucosa. The silk is left in place until it is passed when the hemorrhoidal stump sloughs. This procedure is frequently very painful for a period of one week. Another form of technic is a modification of the old clamp and cautery treatment. A radial, elliptical incision is made through the mucosa at the base of each hemorrhoidal mass, the vessel is dissected out, the mass is grasped in a clamp, and the protruding tissue is destroyed by the cautery. The skin edges are then coapted by fine chromic gut. A light packing well coated with vaseline is left in the anal canal for ten hours. An enema of 8 ounces of sweet oil is passed into the ampulla through a small, well lubricated catheter. The following morning the patient has a bowel movement that is painless. This procedure is repeated each evening and morning until the patient leaves the hospital, usually in five or six days. This method of treatment has resulted in an almost painless convalescence and has reduced the hospital stay by several days. Local anesthesia, 0.5 per cent. of novocaine, or some similar preparation, is usually sufficient in most cases. The anesthetic should be introduced under the skin about the anus and then the mucosa and perirectal tissues are infiltrated by deeper injections. A quarter grain of morphine given hypodermically ten minutes before operation is

helpful in many cases. At times the patient cannot be controlled and a general anesthesia is required. Postoperative bleeding following any method is readily controlled by a graduated pack in and against the anus.

EXAMINATION OF THE RECTUM AND ANUS.

The examination of a patient with an anal or rectal disturbance is not a complicated or difficult affair. Because of some unpleasant associations and more especially because of lack of simple equipment a superficial examination of the lower bowel is frequently omitted when every indication of rectal disease is present. Someone has said that the chief function of a consultant is to make a rectal examination because of the great frequency with which this procedure is omitted.

Visual examination of the anus readily shows external hemorrhoids, external opening of a fistula, or the presence of a swelling indicating an ischiorectal abscess. With slight eversion of the anal mucosa a fissure is frequently brought into view. Much information can be obtained by the insertion of the gloved index finger; a fissure is felt as a hardened strand—the internal opening of a fistula lying in its area of indurated tissue—the resistance of the anal wall in ischiorectal disease —the fullness of the mucosa in internal hemorrhoids—a polyp of the anal canal or ampulla—ulcerations in the ampulla, and the presence of new growths of all kinds in the lower rectum— especially cancer. The central portion of rectal cancer sloughs early leaving an ulcerating center and an elevated indurated margin. Senn described the impression given to the examining finger passing across the margin of the cancerous crater, as similar to that of a lacerated cervix.

A bivalve speculum is helpful in examination of the anal canal, but is useless for thorough examination of the ampulla or higher rectum. Some one of the various forms of proctoscopes that carry an electric light at the tip and are adjusted for positive air-pressure is essential for complete exploration of the rectum to the level of the lower sigmoid. The air pumped in by means of a small hand bulb distends the ampulla to its 3-inch diameter and gives the opportunity for detailed visual examination of the entire mucosa. If it is desired to explore higher the air pressure distends the bowel and the proctoscope is readily carried around the valves of Houston in most cases to the recto-sigmoidal anastomosis. In some instances the proctoscope may be carried to a length of 15 cm. only, 2 cm. short of the cul-de-sac. In others the proctoscope readily passes to a distance of 30 cm. giving a view of the lower half of the sigmoid colon. This variation is due to the short or lax attachment of the gut to the sacral wall by the mesosigmoid and perirectal connective tissue.

The sloughing center, overturned edge of the cauliflower-like mass of cancer once seen is seldom mistaken for anything else. It is a wise precaution to remove bits of the tissue for microscopic examination. The tissue is obtained by a biting forceps at the end of a staff some

inches longer than the proctoscope. No anesthetic is necessary as the rectal mucosa has no nerves of sensation. The presence of the proctoscope, if handled gently, and the cutting of the tissue are practically without sensation in most cases.

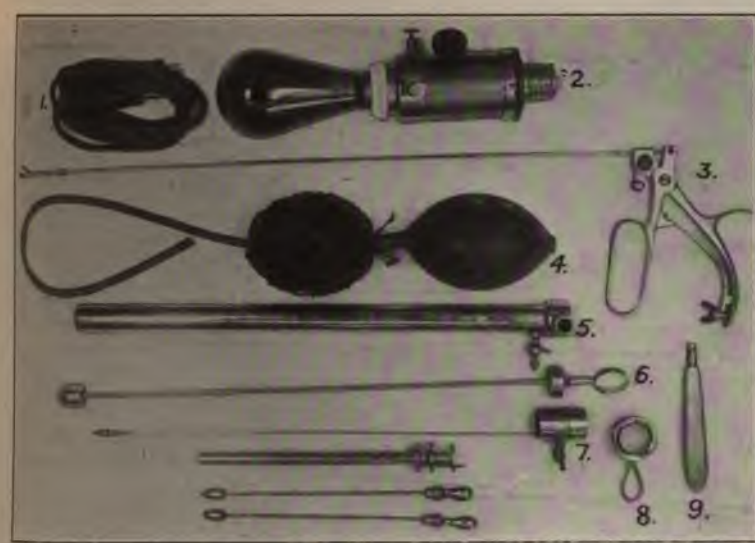


FIG. 87.—A convenient form of proctoscope for examination of the large bowel from the anal canal to the sigmoid. *1*, electric cord; *2*, rheostat; *3*, forceps for excising material for microscopic diagnosis; *4*, bulb which forces air into the proctoscope through the stop cock at the side; *5*, proctoscope from which the obturator *6* has been removed; *7*, electric light which fits down into the proctoscope carrying the light to the distal end; *8*, glass window which fits over the end of *7*, giving air-tight connections; *9*, adjustable handle.

CARCINOMA OF THE RECTUM AND ANUS.

Carcinoma of the Rectum.—A thorough examination of every case of hemorrhoids, or where there is a record of blood in the stools, is indicated to determine the presence or absence of cancer. In one of the larger hospitals of Chicago a review of the histories of rectal cancer showed that 35 per cent. of the cases had been operated from one to three times for hemorrhoids in a period of six months before admission with a diagnosis of cancer.

Diagnosis.—A carefully taken history in each case of bloody stool is often helpful in diagnosis. Anal fissure may give a streak of blood along the side of a formed stool. The passage of the stool is very painful and is followed by rather severe tenesmus due to the spasm of the sphincter and the intense pain of several minutes' duration. There is frequently a record of several drops of blood after the passage of the stool. Uncomplicated hemorrhoids are not accompanied by the tenesmus, and are accompanied by a protrusion of the hemorrhoidal mass in most instances. The bleeding of hemorrhoids is more severe than that of fissure in most cases. Visual and digital examination are usually

sufficient to make a diagnosis. A rectal or anal polyp may protrude into or through the anal lumen, and may be mistaken for a hemorrhoid. A polyp not infrequently bleeds in a manner suggestive of hemorrhoids. A polyp in the ampulla is readily detected by the proctoscope.

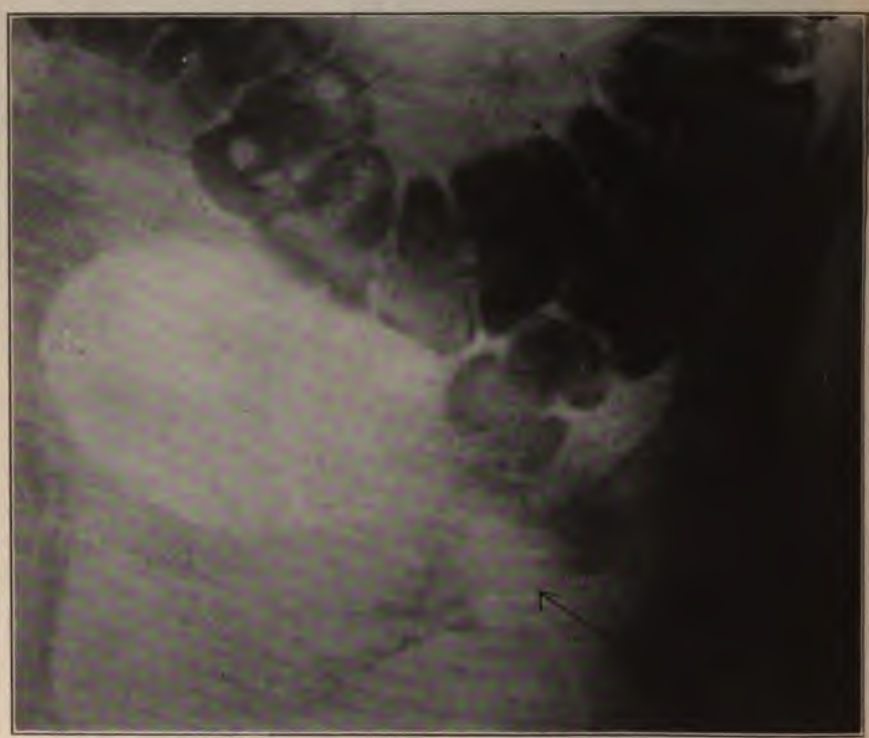


FIG. 88.—The large gut, proximal to the tumor of the sigmoid located at the point indicated by the arrow, was distended by barium forced through the malignant stricture. The patient was then given a plain water enema to remove all the barium possible from the bowel. The portion of the bowel distal to the tumor was emptied with a cleansing enema, leaving the condition shown in the picture. A somewhat similar picture results when the patient is given a barium meal.

The bloody stool of rectal cancer differs from all the above in that it is a diarrheal stool. It is most active when the patient is first on his feet each day; hence it has been termed "the morning diarrhea of rectal cancer." During the night with the patient in a prone position there is an accumulation of bloody pus and serum in the bowel above and below the level of the disease. As the patient assumes the upright position there is a precipitation of the irritating contents into the ampulla and he makes frequent attempts to obtain relief during the early forenoon. During the afternoon and evening there are less frequent stools. The morning diarrhea is very rarely present without the visible blood.

X-ray Examination.—Roentgen-ray examination of the rectum is helpful at times in determining the presence of stricture, both by fluoroscopic observation of the rectal enema of barium as it traverses the bowel, and by plates to record the deformity that may be present. It is infrequent that the carcinoma is found before deformity of the outline of the bowel is seen by such an examination. Of course, one must not confuse peristaltic incisuræ with stenosis.

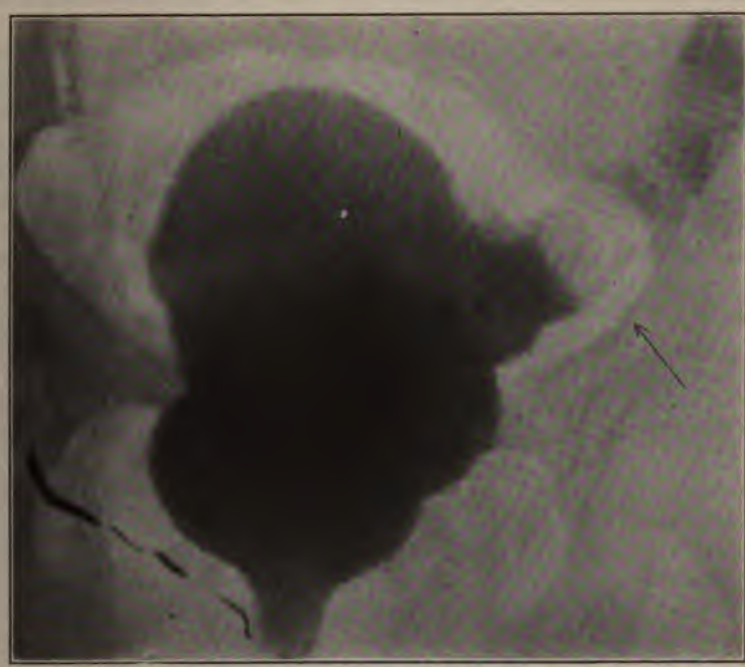


FIG. 89.—A barium enema was given, distending the bowel up to the level of the sigmoidal tumor. The site of the tumor is indicated by the arrow. A small amount of barium has escaped through into the proximal portion of the gut.

Preparation of the Patient.—The preparation of the patient is not such a complicated undertaking now as was formerly the case. A cathartic forty-eight hours before operation to empty the lower bowel is helpful. It is better not to give a cathartic the night just previous to the operation as there is a tendency to dehydration. An enema the evening previous and the morning of the operation are sufficient to empty the rectum. The usual diet is maintained through the day previous to the operation so as to disturb the metabolism as little as possible. The day and evening before the operation the patient should be encouraged to drink as much water as is comfortable.

Treatment.—There is no fixed type of operation for cancer of the rectum. There is a large variation in technic depending on the age, sex and condition of the patient. The location of the tumor has a large predisposing influence. The determination of the patient himself

for some form or other of technic is at times the last word. There is a difference of opinion among surgeons as to what is the predisposing element. Immediate and ultimate mortality and functional result are standards of one's surgical judgment. One type of operation may show a very low immediate mortality but may have a big percentage of recurrences. Another form of technic may have low ultimate mortality but may show a high early mortality or a poor or good functional result. According as one may value these three factors there is a swing in the valuation of each procedure.

Carcinoma of the Anal Canal.—Cancer of the anal canal is a flat cell tumor following the type of epithelium found there usually. The disease involves the sphincters early and passes downward in the lymphatic stream to the inguinal glands. Radical treatment of this form of cancer demands amputation of the bowel through the lower ampulla above the anal canal, and removal of the anal canal and sphincters. The rectum is pulled down and the ampulla is fixed in the wound and the skin edges drawn down and sutured to the mucosa. The region is covered with vaseline for protection against the fécal discharge. This is known as the Harrison Cripps method. The control of this type of termination is better than appears at first sight. By compression of the buttocks the patient attains a fair amount of control during an emergency. There is constantly enough muscular tone for the patient by means of a compress to get along with some comfort.

Carcinomatous involvement of the inguinal glands is usually considered a contra-indication for radical treatment. However, I have one patient still alive, and apparently in good condition, after a period of almost three years, who was given a radical removal of the bowel and inguinal lymph glands for cancer in the anal canal and inguinal region. This patient if not cured has certainly had a more comfortable existence and possibly has had an extension of life.

A temporary colostomy is not necessary in operating for carcinoma of the anal canal.

Carcinoma of the Ampulla.—Cancer of the ampulla is a more difficult condition because of its higher position and upward lymphatic drainage. A portion of the ampulla may be resected and the bowel then brought down through the sphincters in an effort to regain normal function. This is not successful in most instances, due to the fact that the sacral nerves to the sphincters are destroyed in removing the diseased segment. Because of sphincter loss the end of the rectum is brought out in the posterior wound and sutured at a higher level than the former anal outlet. This type of anus is most unfortunate in that there is no control except by means of a compression apparatus, which causes ulceration of the mucosa sooner or later. As soon as the fecal current passes into the descending colon there is a rapid descent and escape of contents; the patient is unable to determine his exact condition by visual examination, and is at a great disadvantage.

A preliminary, temporary colostomy is an added safeguard in all

procedures involving amputation or resection of the ampulla. In this way the bowel contents are removed from the field of operation until healing is complete. Not infrequently slight yielding of the stitches in the sacral region gives entrance of the fecal current into the pelvic structures with serious results—long standing infection or death.

Carcinoma high in the ampulla or at the recto-sigmoidal junction demands opening of the peritoneal cavity either by way of the pouch of Douglas or through the anterior abdominal wall. Some operators of

FIG. 90.—The relation of the rectum to the ureters as they pass forward to the bladder.

great experience in this field insist on terminating these cases in the sacral region. Hochenegg is chief among these. Where the tumor is situated high-up it is necessary to ligate and incise the superior hemorrhoidal artery to free the rectum from its vascular attachment, and pull down the sigmoid loop of gut to permit the distal end of gut to emerge on the posterior wound. Patients are not infrequently lost if this procedure is followed, due to the fact that the surgeon in clamping and cutting may shut off the vascular supply to the parts below the last anastomosis of the marginal artery, which is the branch from

the sigmoidal artery. These patients usually die at the end of the first week. If, for any reason, the decision is made to terminate the bowel in the sacral region in this type of cases, it is always much safer to establish a temporary colostomy at the same operation or at an earlier time.

A more thorough method of handling these cases is to operate by the so-called combined route, or abdomino-sacral method. This route certainly has a greater primary mortality, but, as has been pointed out by the Rochester Clinic, there is a larger percentage of living patients at the end of three years than by the sacral route.

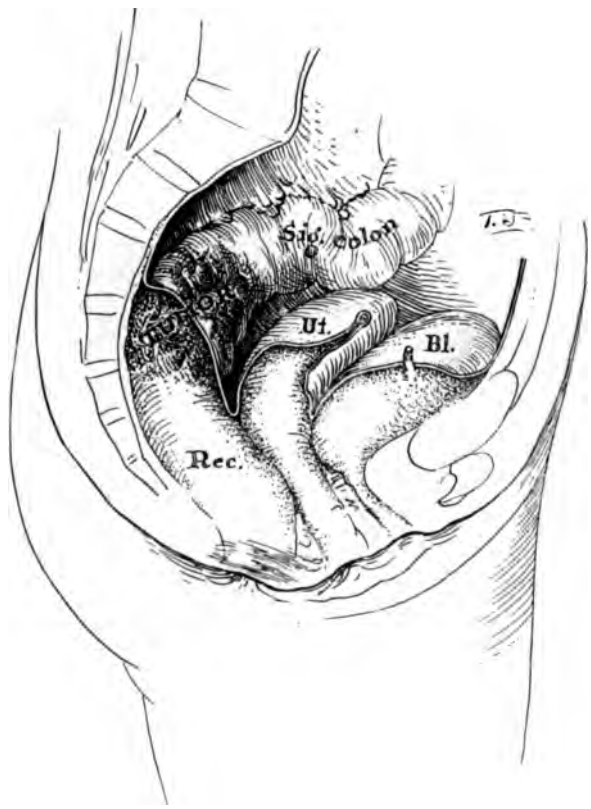


FIG. 91.—When the carcinoma is located in the region as shown, a two-stage operation is indicated.

The combined route consists of sectioning the gut at the level of the sacral promontory, bringing the proximal end through a stab wound in the left abdominal wall. The superior hemorrhoidal vessels are ligated and cut. The bowel is freed down to the level of the levator ani muscles laterally, and in the front to the posterior vaginal fornix in the female and to the seminal vesicles and the prostate in the male. The gut is pushed down and the peritoneum sutured across the pelvis

leaving the telescoped gut extraperitoneal. The abdomen is closed and the rectum removed by the sacral incision after the coccyx is amputated. It is safer to do the work in the male with a sound or catheter in the urethra.

The abdomen is opened for several reasons. Probably the most important of these is the information gained concerning the extent of the disease. In older persons cancer may travel to the liver probably by the portal system, without any gross evidence of disease in the aortic glands or the lymphatics high in the hemorrhoidal group.

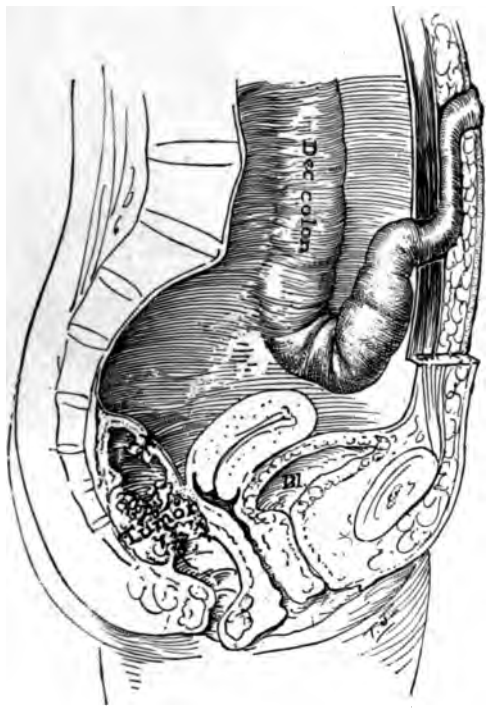


FIG. 92.—This sketch indicates the anatomy at the end of the first stage, or abdominal portion of the combined operation. The pelvic peritoneum is sutured above and not to the invaginated distal segment. The superior hemorrhoidal artery and vein with accompanying fat and lymphatics are removed from the hollow of the sacrum. When this is done secondary operation must be done by the end of the first week.

Younger people up to thirty-five years of age may show malignant involvement of the lymphatic glands in the mesosigmoid without any hepatic involvement. When the abdomen is opened the bowel is usually terminated on the abdomen as a permanent colostomy. At times, however, the abdominal incision is used to mobilize the gut sufficiently to permit the sigmoid to slip down for a termination of the gut in the region of the sacral or posterior incision. The combined route is frequently done in two stages to divide the burden of shock. The amount of work done at the first stage is varied. When the patient

is aged or exhausted by disease, it is wise to cut the gut close at both ends, draw the proximal end through the abdominal wall and drop the distal end free in the peritoneal cavity. After one to four weeks, when the patient has gained greatly in strength and somewhat in weight, the distal segment of gut may be removed by the sacral route or by a combined technic. The plan of sectioning the gut, partially mobilizing

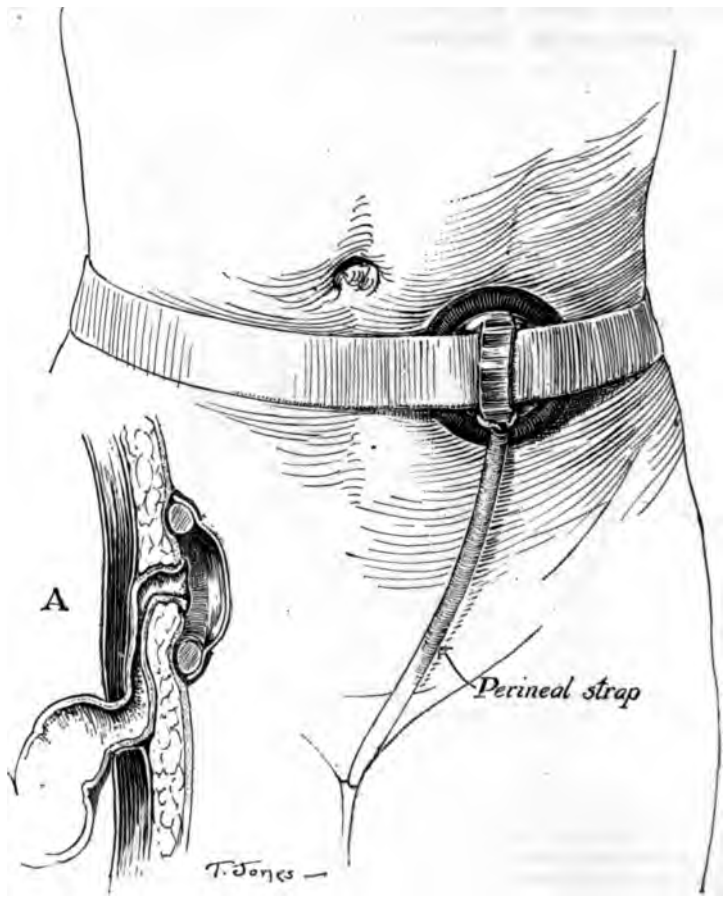


FIG. 93.—Colostomy cup and belt. If the loop is long and redundant a receptacle is formed within the body. This will accumulate the fecal contents if flushed once in twenty-four hours. The cup is of metal with a rubber ring. This apparatus is cleansed more readily than a rubber bag arrangement and is free from the fecal odor that clings to a rubber bag with whatever cleansing is done.

the distal segment and pushing it into the pelvis and then closing over with pelvic peritoneum is dangerous, as necrosis and infection frequently result with an occasional death.

Where the patient is not old and the general condition is good, there is a temptation to do the entire combined procedure at one sitting. There is a strong tendency developing among surgeons, however, to

do the work in two stages. One must constantly bear in mind that these patients are greatly weakened by the toxins of the disease, and in addition are exhausted and dehydrated by the continued diarrhea. Whatever method the surgeon uses he becomes disheartened by his losses and turns from one step to another and back in the same old track until finally the two-stage procedure or preliminary colostomy becomes crystallized as a part of his technic.

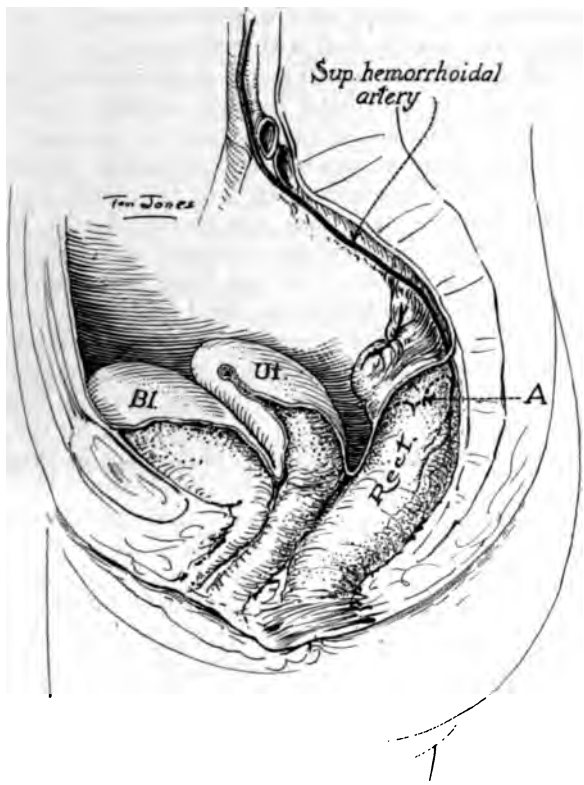


FIG. 94.—Permanent treatment of the distal stump when carcinoma is present in the sigmoid at a point too low for a lateral anastomosis. In this case the bowel is terminated on the abdomen, and the superior hemorrhoidal, arterial and venous supply are preserved.

The mortality of operative treatment high in the rectum varies with the sex—being low in women and high in men because of the relation of the genitalia. The low mortality of women is due to the fact that extension forward of the disease merely involves the posterior vaginal wall. Excision of the recto-vaginal wall is simple. Extension forward of the disease in the male involves the seminal vesicles or prostate. Dissection of the rectum from the region of the male genitalia occasionally results in injury of these structures and a seminal fistula with subsequent ascending infection and pain.

When this method is employed, the operator is between two fires. It is better to clean out the entire sacral fossa in order to take away all the carcinomatous tissue that is present. On the other hand, if we cut off the blood supply by removing the arteries and veins, there is great danger of necrosis of the distal segment and sepsis to the patient, especially in those cases in which the condition of the patient does not permit of the second stage of the operation before the end of the first week.

If the carcinoma is located at the recto-sigmoidal junction, and the lower segment is not covered with peritoneum, it is dangerous to attempt an end-to-end anastomosis as the point at which the proximal segment is attached to the distal segment usually develops a fecal fistula. The peritoneal coat on each segment is necessary to obtain a safe union. The operator then has a choice of two procedures. He may pull the proximal segment down into the distal segment, telescoping the line of suture, or he may give up the effort to preserve the continuity of the gut and free the proximal end out through the abdomen and leave the portion of the gut distal to the carcinoma in its normal position. This resection in the distal segment is not dangerous as the lymphatic drainage of this portion of the gut is upward.

A further reason for the high mortality rate of the abdomino-sacral method is that cases inoperable by the Kraske or sacral route are bad risks to start with. If we operate on such a patient by the combined route and the patient dies, the mortality should not be charged to the combined operation as compared with the sacral route.

In addition to immediate mortality we should consider the ultimate mortality or prognosis after operation. Hartman of Paris collected several thousand cases of cancer of the rectum treated surgically. For the various forms of sacral or perineal operation he found an immediate mortality of 15.8 per cent. with a recurrence of 68.1 per cent. For the combined operation he found a mortality of 37 per cent., including the statistics of the older operators, and a recurrence of 18 per cent. Thus 37 per cent. plus 18 per cent. shows an ultimate mortality of 55 per cent. in patients operated by the combined procedure. But 15.8 per cent. plus 68.1 per cent. shows an ultimate mortality of 83.9 per cent. in patients operated by the single posterior route.

The abdominal anus, if properly constructed with a low hanging loop in the abdomen, is far less subject to unpleasant accidents when the bowels are loose; and is under the vision of the patient, and thus is more readily handled and cleansed than is the sacral anus.

ACUTE RENAL INFECTION.

By GEORGE EMERSON BREWER, A.M., M.D., LL.D.

The acute surgical infections of the kidney form an interesting and important group, which vary considerably in their clinical manifestations, in the character of their pathological changes and in the degrees of toxemia which they occasion. They must be sharply differentiated from the chronic infections, as the tuberculous, the rare syphilitic or the still rarer mycotic processes, although some of these occasionally will present symptoms of an acute character. For the most part these acute infectious processes result in circumscribed or diffuse areas of parenchymatous suppuration, which later may extend to the tissues of the renal pelvis and ureter; but in rare instances the process, even though a virulent one, may give rise to lesions which on gross inspection appear only to be necrotic in character.

All are associated with an active hyperemia of the organ and a more or less extensive impairment of its function. The cause of the infection, in every instance, is the presence in the renal parenchyma of pathogenic microörganisms which may be brought to the organ by a penetrating wound; by extension from a neighboring septic focus, either by direct continuity of tissue or by the lymph stream, by an ascending process from the lower urinary passages or by the blood current.

Infection of the kidney by a direct penetrating wound, carrying infection to the organ from the outside, is of fairly frequent occurrence. The majority of such instances result from gunshot injuries, stab wounds or as a sequel of severe traumata by blunt objects. The infection in these instances is due to the direct transference of infected matter from the surface of the body, the clothing, or from the injuring missile, to the renal tissue; and once implanted in this favorable culture medium the pathological process is as simple and well understood as in an infection of the skin or cellular tissue. The diagnosis in these cases is easily made from the history of the accident, the presence of the wound in the neighborhood of the kidney, the local discharge of urine and the ordinary manifestations of renal infection, which will be considered later.

Infection of the kidney by direct extension from a neighboring focus through the renal capsule or tissues of the pelvis, while possible by traversing adhesions between contiguous tissues or through the lymph channels, is so rare as to constitute a veritable surgical curiosity. In this connection it might be stated that certain colon bacillus

infections of the kidney have been explained by an assumed direct transit of pathogenic organisms from the duodenum or colon to the renal substance as a result of a severe enteritis or ulcerative process located in the region of the bowel in contact with the kidney. So far as I am aware this has never been proved experimentally, although the occasional occurrence of an acute peritonitis by the transit of microörganisms through the inflamed but unbroken wall of the intestine or appendix, is suggestive and would render the possibility of this method of infection of the kidney an interesting study. The extreme rarity of these cases, however, and the fact that, like the first group, the infection reaches the kidney by a direct and easily understood route and develops as in any other tissue, would render an extended discussion of this type superfluous.

It is, however, with the last two methods of infection, the ascending and the hematogenous, that the surgeon has largely to deal, as these constitute by far the largest group of clinical cases.

ASCENDING INFECTIONS.

General Considerations.[1]—Long before the days of kidney surgery, the occurrence of renal suppuration was frequently observed, and the classical lesions, pyelonephritis, pyonephrosis, renal abscess and perinephritis, described pathologically and occasionally recognized clinically. The frequently observed pathological picture presented by the autopsy of a patient dead from renal infection following prostatic enlargement or ureteral stricture, showing the chronic long-standing cystitis, the dilated ureter and renal pelvis exhibiting more recent inflammatory changes, and the still more acute suppurating areas in the renal parenchyma, and the demonstration of the same species of pathogenic bacteria in all of these situations, led to the belief that the great majority of renal infections occurred by an ascending process from the lower urinary passages.

In 1890 Guyon and Albarran demonstrated, by animal experiments, that virulent cultures of pathogenic microörganisms injected into the healthy bladder gave rise to no demonstrable lesion of the bladder, ureters or kidneys. If, however, the bladder contamination was associated with urinary retention, produced by ligation of the urethra, an acute cystitis resulted, with a later infection of the renal pelvis and parenchyma. Zemblinoff sought to explain this ascent of microorganisms through the ureter, during retention, by an antiperistaltic

[1] In this section and in that dealing with the clinical aspects of the subject, the author has drawn largely from his previous communications on renal infection, including: The Present State of Our Knowledge of Acute Renal Infections, with a Report of Some Animal Experiments, the Oration in Surgery delivered before the American Medical Association, June, 1911; Type Rare d'infection Hématogène Unilateral des Reins, read before the Association Française de Chirurgie, Paris, 1910; Hemic Infections of the Kidney, presented at the Seventeenth International Congress of Medicine at London, 1913; Acute Unilateral Hematogenous Infections of the Kidney, presented at the meeting of the American Surgical Association, and the third edition of Brewer's Text-book of Surgery, Lea & Febiger, 1915.

action on the part of the ureteral musculature. This view, explaining as it did the phenomena of ascending infection, was for a time generally accepted until discredited by a second series of experiments by Guyon and Albarran, in which they injected into the bladder inert colored particles of vegetable charcoal and various species of bacteria, and by producing an artificial retention, as in the former experiments, noted the results in each series, particularly the relative time necessary for the inert powder and living organisms to reach the renal pelvis.

It was found that, under conditions of complete urinary retention, forty-eight hours were necessary to effect the transfer of particles of charcoal powder to the renal pelvis, and even then they were found only in minute quantities; while the living bacteria were demonstrated in considerable numbers in three, nine and a half and twelve hours from the time of inoculation. This difference the authors ascribed largely to the motility of the organisms, which certain species of bacteria as the colon bacillus, are known to possess to a very considerable extent.

The length of time which elapsed before the charcoal powder could be detected in the renal pelvis effectually disproved any real muscular antiperistaltic action. Some years later Ajevoli explained the ascent of inert particles or bacteria in the ureter, under conditions of urinary retention, as due to the ordinary laws of hydrodynamics, according to which, while the main current of fluid in the dilated ureter would move slowly downward, counter-currents, eddies, and, to a certain extent, to-and-fro movements, would be present which would account for the slow diffusion of particles contained in the ureteral urine and their gradual ascent to the renal pelvis.

Following these original experiments many confirmatory observations were made and published both in France and Germany, among which may be mentioned those of Lœwin and Goldschmidt, who demonstrated the ease with which an ascending infection could be produced in rabbits as contrasted with the difficulty in producing it in dogs; and those of Albarran, in which he invariably produced the typical picture of a severe ascending pyelonephritis by the injection of pathogenic organisms into the proximal segment of a ligated ureter. These positive results were produced by a variety of organisms, as the Bacillus coli, Streptococcus pyogenes, Staphylococcus pyogenes aureus and a liquefying bacillus described by Albarran. In the human subject the colon bacillus was thought to play the most important rôle, for in 25 cases reported by Guyon it alone was responsible for the infection in 16 while in 7 others it was present with other organisms as a mixed infection.

In 1898 Roovsing published the results of a series of animal experiments and clinical observations which cast considerable doubt on the importance of the Bacillus coli in the causation of renal infection. While admitting that the colon bacillus gave rise to a certain number of comparatively mild infections of the urinary passages, he expressed the opinion that in the great majority of the graver infections the causative microörganism was one of the pyogenic cocci or some other

organism capable of decomposing the urea and giving rise to ammoniacal urine, and this view has been widely accepted by later observers.

In 1894 Courtade and Guyon published the results of an interesting group of experiments which tended to show that the protection of

FIG. 95, *A*.

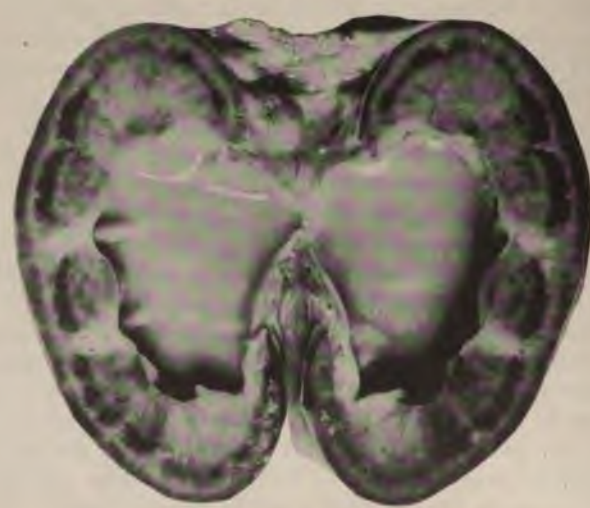


FIG. 95, *B*.

FIG. 95, *A* and *B*.—Experimental pyonephrosis, showing normal and infected kidneys from a dog, following unilateral ureteral infection, with subsequent occlusion, Fig. *A* indicating the normal and Fig. *B* the infected kidney.

the kidney against an ascending infection from the bladder lay in two important factors: (1) The constant downward current in the ureter, which even when a reflux occurred admitting contaminated urine from an infected bladder into the ureter, constantly swept the infected

material downward and finally again forced it outward into the bladder, and (2) the protective mechanism of the intravesical portion of the ureter. This by its oblique transit through the vesical wall and the presence of a girdle of encircling muscular fibers from the

FIG. 96, *A*.

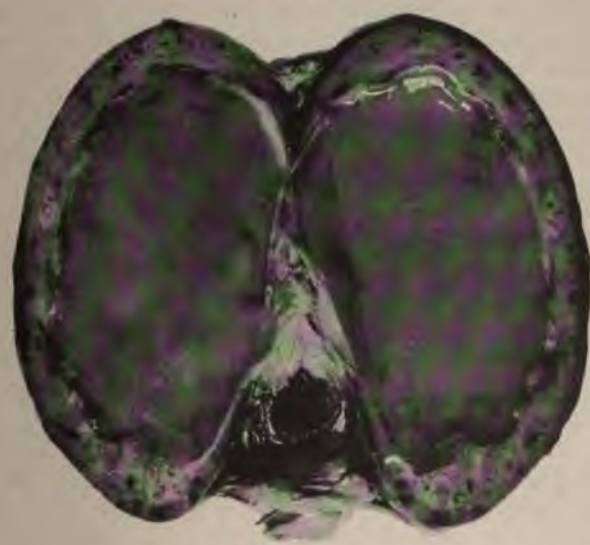


FIG. 96 *B*.

FIG. 96, *A* and *B*.—Experimental pyonephrosis, showing normal and infected kidneys from a dog, following unilateral ureteral infection, with subsequent occlusion, Fig. *A* indicating the normal and Fig. *B* the infected kidney.

bladder wall allows no backward reflux of fluid from the bladder under normal conditions of bladder rest and contraction. Gradual distention, when unassociated with muscular contractions, even to the most extreme degree, does not permit the ureteral reflex. Distention, even moderate in extent, when associated with muscular contractions,

particularly when this muscular contraction or spasm is premature, involuntary or reflex in nature, does allow an opening of the ureteral orifice and a reflux of bladder urine into the ureter. In uninfected bladders these conditions eventually lead to a permanent gaping of the ureteral orifice and dilatation of the ureter and renal pelvis, a condition frequently present in elderly men with prostatic enlargement or chronic urethral stricture.

In 1911 the author reported a series of animal experiments on ascending infection[1] which tended to confirm the views of Albarran and Guyon, in that no amount of bladder infection would result in an ascending pyelonephritis unless the added element of retention or vesical irritation were present.

Direct infection of the ureter, however, with later occlusion, invariably resulted in typical pyonephrosis, as illustrated in Figs. 95 and 96. In this report the author commented on the great difficulty experienced in producing an ascending infection in animals, which contrasted sharply with the ease with which in another series of experiments he produced renal infections by the blood current.

In 1912 Stewart called attention to the possibility of an ascending process from the bladder to the kidney, not by the lumen of the ureter, but by the lymphatics in its outer coat. While the author has not as yet been able to produce an infection by this method in animals, numerous autopsy findings in human subjects seem to demonstrate the existence of this type. From the fact that only the outer or fibrous coats of the bladder and ureter are rich in lymphatics it would seem probable that this route of infection would follow most frequently the deeper or interstitial forms of cystitis.

From a review of the known pathological evidence and the experimental investigations of others, and from our own animal research studies and clinical experience, I feel that we are justified in making the following statements:

1. An ascending infection is responsible for a certain proportion of the acute surgical infections of the kidney.

2. In the great majority of such instances the infectious material is carried upward to the kidney by a reflux of contaminated urine into the ureter and renal pelvis through the ureteral orifice as the result of some interference with its protective mechanism. The factors which favor this process are, in the order of their importance, a chronic obstruction to the normal bladder outflow, as urethral stricture, obstructive prostatic hypertrophy and prostatic or vesical new growth; acute cystitis with severe tenesmus and violent expulsive efforts; severe inflammation, ulceration, calculus or new growth involving the ureteric orifices, interfering with the normal sphincteric action; ureteral and detrusor paralysis from spinal injury or disease; the possible temporary paresis of the ureteric sphincter by the passage of a large ureteral calculus.

[1] Oration in Surgery, Jour. Am. Med. Assn., vol. lvii, p. 179.

3. In certain rare instances the process may occur by a direct extension of the inflammation along the mucous membrane of the ureter by continuity of tissue, as proved by numerous clinical observations.

4. In other rare instances the infection may ascend by the ureteral or peri-ureteral lymphatics, and this is more likely to occur if there exists an infection in the deep structure of the bladder wall involving the vesical lymphatics.

5. As stated by Legueu, these methods in certain cases may be combined and concomitant.

HEMATOGENOUS INFECTIONS.

General Considerations.—This group of cases constitutes by far the most interesting series in all renal pathology, embracing, as it does, cases illustrating the greatest variety in regard to etiological factors, and the greatest difference in virulence, symptomatology, prognosis and therapeutic indications. While in the ascending group of infections we have but a single predisposing etiological element to consider, namely, an infection of the bladder; in the hematogenous infections we may have as a predisposing factor any infection of any degree of virulence in any tissue or organ of the body, as well as any general infectious disease, as typhoid or typhus fever, scarlatina or any of the other exanthemata; grip, tonsillitis or pneumonia; a furuncle, paronchia or an infected wound; a cold in the head or possibly only a simple chronic constipation.

In virulence these infections may vary from a slight transitory febrile attack, without local manifestations, to the most profound and rapidly fatal toxemia, with complete disorganization of one or both kidneys and the entire suspension of renal function; in symptomatology from a slight sense of malaise, with or without local discomfort, to the classical clinical picture of advanced renal suppuration; in prognosis from the mildest of recognizable maladies to a condition which from the first admits of nothing but a fatal outcome; in treatment, from mere expectancy to decapsulation, drainage or an early primary nephrectomy in the unilateral type.

The frequent association in autopsy findings of renal suppuration, with cases of pyemia, septicemia, erysipelas, endocarditis and other fatal septic conditions, had been observed by pathologists for many years before its significance was appreciated.

It was perhaps Lannelongue who, after observing this association in 7 out of 10 fatal cases of osteomyelitis, first emphasized the importance of renal infection through the blood current, independent of the fatal general blood infections.

Albarran, in 1889, published the results of his epoch-making experiments in renal infection which demonstrated that the ordinary pus cocci may, under certain conditions, be eliminated through the kidneys without producing marked anatomical lesions; their elimination, on

the other hand, may give rise to a bacteriuria, to a glomerular nephritis with degeneration of the epithelium, to multiple non-pyogenic infarcts, to pyogenic infarcts giving rise to multiple abscesses, to perinephritic abscess, to pyelonephritis or to a rapidly fatal toxemia. He also stated that the effects of trauma, excessive functional activity, the presence of toxic products and renal retention all served to accentuate the process and to favor the formation of graver lesions. Pernice and Scagliosi, in 1891, reviewed the work of Albarran and published in *Virchows Archiv.* the results of an elaborate series of experiments showing the anatomical lesions produced in the kidneys by the excretion of various types of pathogenic and non-pathogenic bacteria.

Israel, in 1891, called attention to the possibility of grave renal suppuration being due to microörganisms entering the blood current from comparatively mild local infections as furuncles, paronychias, carbuncles, etc., while Jordan, some years later, reported 12 cases in which the original source of infection was definitely traced to such insignificant peripheral lesions.

Prior to the year 1889, when Albarran published his experimental studies in renal infection, the opinion prevailed in the profession that the presence of pathogenic bacteria in the blood current generally meant the death of the individual from pyemia, with metastatic foci in the various organs and tissues of the body. These experiments, and to a certain extent, also, more accurate clinical observation, gradually brought about a change of opinion in this matter, and it was finally conceded that a given blood infection might be mild in character and only produce metastasis in a single organ, joint or superficial tissue, accessible to surgical intervention; and that if this focus could be accurately located and drained recovery might ensue.

The experiments of Pernice and Scagliosi further demonstrated that moderate quantities of these organisms could, under certain circumstances, circulate in the blood without necessarily producing gross lesions, and might eventually be excreted through the kidneys without or with but slight structural changes in these organs; but that if the one or both kidneys were diseased or possessed a diminished resistance against infection from trauma or other grave disturbance in nutrition, lesions were produced which would vary from a slight cloudy swelling or glomerular nephritis to complete destruction of the renal tissue by purulent infiltration or necrosis.

About this time clinicians, notably Israel, Semon and Alexander Johnson, called attention to the significant fact that in these blood infections the disease was often unilateral, and that even the gravest suppurative lesions could be successfully attacked surgically so long as the opposite kidney remained functionally competent. This fact was subsequently demonstrated to be correct by the more general employment of cystoscopy and ureteral catheterization.

Some years ago the writer undertook a series of animal experiments with a view to determining, if possible, the various factors which caused a given blood infection to attack a single kidney and also

PLATE II

Lumier Photograph of Acute Hematogenous Infection—
Advanced Stage. (Brewer's Surgery.)

to study the pathological processes and the lesions produced. Considerable difficulty was at once encountered in regulating the dose of the culture employed. If the amount injected into the circulation was too large, or if the virulence of the particular organism was too high, the animals would succumb promptly to an overwhelming toxemia, and the autopsy would show only acute hyperemia and cloudy swelling of the various organs. If the dose was somewhat milder the animals would occasionally live for four or five days and the autopsy would then show a general septic process, with metastatic infarcts or miliary abscesses in the lungs, liver, spleen, and kidneys. If the dose was still milder the evidences of a generalized metastasis would be lacking, but the kidneys would almost invariably show infarcts and suppurative areas. If the dose was still further reduced or the virulence of the organism exceedingly low, the kidneys would exhibit no septic areas, only a moderate parenchymatous degeneration.

My first group of experiments consisted in producing a mild bacteremia in rabbits and dogs by injecting into the ear vein cultures of various pathogenic organisms and lowering the resistance of one kidney by various degrees of trauma, by the introduction of a foreign body simulating stone or by the production of an artificial hydronephrosis.

In a second series, undertaken several years later, an effort was made to determine the effect of anemia, passive hyperemia and other vascular changes in lowering the resistance of a kidney to blood infection.

All of these experiments were published in detail in 1911,[1] and from an analysis of the results obtained it was evident that when the bacterial dose was properly adjusted to the size, weight and individual resistance of the animal, so as not to produce an overwhelming general infection, the uninjured kidneys rarely showed septic lesions; while in the traumatized or irritated kidneys definite lesions were almost invariably demonstrated. Of 11 experiments in which the injured kidney exhibited typical suppurative lesions, in only 3 instances were septic foci found in the opposite or normal kidney; and in 2 of these the lesions were exceedingly mild and infrequent. In 1 experiment only were the septic processes in the two kidneys found to be equal in extent or virulence (Figs. 97, 98 and 99).

In reviewing the microscopic study of the lesions produced in these experiments, definite lesions, when present, were found identical with those observed in our clinical hematogenous infections. In most instances they were found to be due to a plugging of the smaller arteries and capillary vessels with groups of organisms. These minute emboli are later surrounded by an encircling zone of round-cell infiltration. When the larger trunks are thus involved, triangular infarcts are present; when the capillaries only are involved, minute abscesses are seen throughout the cortex and beneath the capsule. If the process is allowed to go on the bacterial emboli are rarely recog-

[1] Jour. Am. Med. Assn., vol. lvii, p. 179.

nized; only areas of necrosis and purulent infiltration are found. A
a still later stage many of these collections of pus coalesce, formin

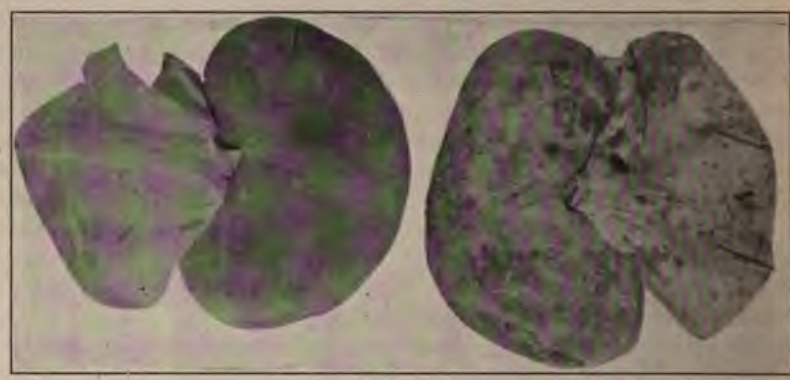


FIG. 97

FIG. 98

FIG. 99

FIGS. 97, 98 and 99.—Experimental hematogenous renal infection, showing normal and diseased kidneys.

large parenchymatous abscesses, which may rupture through the capsule, giving rise to a perinephritis, or into the pelvis, giving the typical picture of pyelonephritis. In some of the cases the condition has been described as an acute purulent interstitial nephritis. In our opinion all of these appearances are but different stages of the same process (Figs. 100 and 101).

From a study of the experiment data obtained from the literature, from my own personal observation and from the accumulated clinical experience during the past two decades, we may conclude: (1) That during the progress of any acute infectious disease a certain number

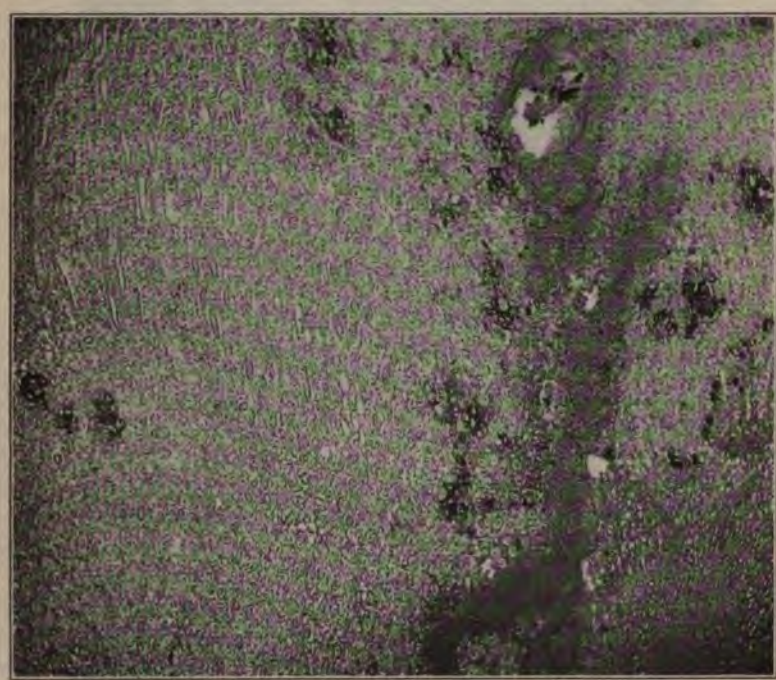


FIG. 100.—Microscopic appearance of section of diseased kidney. Experimental. (Low power.)

of microörganisms find their way into the blood current, and that many of these organisms are excreted through the kidneys. If the number of these organisms is comparatively small, if their virulence is low and if the kidneys are in a healthy condition, the transit of these organisms through the renal apparatus gives rise to no demonstrable lesion. If, on the other hand, the number of organisms is large, if their virulence is high, or if one or both kidneys are diseased, lesions are produced which have been described above, and which may, at the outset, produce an overwhelming and fatal toxemia or may proceed more slowly to the development of any of the classical types of renal infection or suppuration. (2) That while the disease may be bilateral

in a large number of instances it is unilateral, and that its unilate character is due to the fact that the affected kidney has lost to so extent its normal resistance to infection by trauma, abnormal mobili previous disease, calculus irritation, anemia, passive hyperemia, cc plete, incomplete or intermittent hydronephrosis. (3) That while

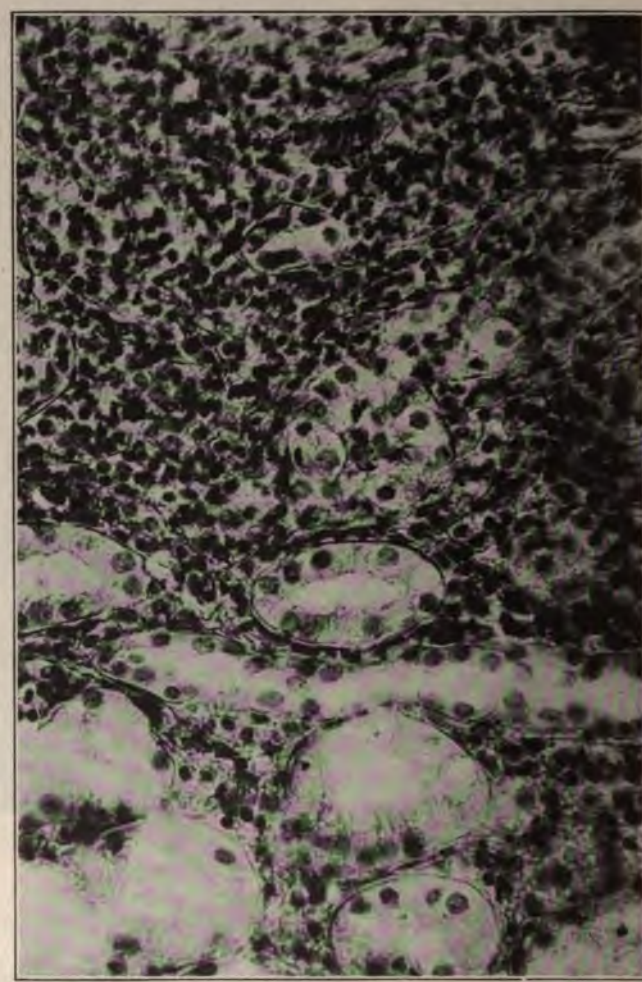


FIG. 101.—Microscopic appearance of section, showing edge of infarct. (Clinical ca

have been able to produce these lesions in animals by the Bacillus c the Streptococcus pyogenes, the Staphylococcus pyogenes aureus, Bacillus typhosus, the pneumococcus and the pyocyaneus, in clini cases we have only been able to isolate the first four of these organis

From a clinical and experimental study of these two types of re infection, namely, the ascending and the hematogenous, I have be

impressed with the great difficulty in producing in animals an ascending nephritis, which is in marked contrast to the ease with which it is possible to induce a hematogenous infection. This would seem to corroborate the impression derived from clinical observation that hematogenous infection was responsible for the greater number of cases of renal sepsis, and would tend to establish the fact, to which Israel and others have already called attention, that even in septic conditions of the lower urinary passages the concomitant renal lesion may be of hematogenous origin.

It will thus be seen that both the ascending and blood infections of the kidney may give rise to lesions which on gross inspection appear identical, and each may result in three degrees or types of infection: (1) The acute fulminating, often rapidly fatal, associated with an overwhelming toxemia; (2) the subacute, progressing slower and resulting in the classical types of renal suppuration as pyelitis, pyelonephritis, pyonephrosis, renal abscess or perinephritis; (3) a mild type which recovers spontaneously and presents no surgical indications.

SPECIAL TYPES OF RENAL INFECTION.

Acute Ascending Infection of the Kidney.—The commonest type of this variety of renal infection is seen in the aged victims of chronic urinary obstruction from old ureteral stricture or prostatic hypertrophy. In these cases the bladder often is enormously dilated with both ureteral sphincters open or easily forced by severe straining or tenesmus. Into this bladder, infection may be introduced by the first passage of a catheter, often for purposes of diagnosis. When this occurs death frequently results within ten days from acute bilateral pyelonephritis.

Diagnosis.—In these cases the symptoms are characteristic but often fail to impress a careless medical observer as being due to renal infection on account of the absence of lumbar pain. The first relief from the bladder distention is followed by a short period of freedom from all symptoms; then follows a chill, with rapidly rising temperature, headache, anorexia, great weakness and a diminished secretion of urine. Later, the urine appears smoky, and finally suppression occurs, with delirium, coma and death. In these rapidly fatal cases both kidneys are involved in the process. In a few instances the infection seems either limited to one kidney or the second kidney is but slightly involved. In these cases the symptoms are those of a rapidly advancing sepsis without suppression of urine; and if the process continues sufficiently long, signs of a unilateral septic kidney may result, as localized pain, tenderness and possibly the presence of a sensitive renal tumor. Cystoscopy and ureteral catheterization may aid greatly in the diagnosis and in furnishing indications for treatment.

Prognosis.—Except in the rare unilateral cases the prognosis in this acute fulminating type is exceedingly grave. In the unilateral cases life often may be saved by a timely operation.

Treatment.—In the bilateral cases the indications are to drain the bladder and to administer diuretics and urotropin. Proctoclysis by the Murphy drip method or intravenous saline infusions are of value, and the question of double renal decapsulation may be considered. In the unilateral type, nephrotomy, with drainage or nephrectomy, may be employed in suitable cases.

The choice of cases for nephrectomy depends (1) upon the extent to which the kidney is diseased, and (2) upon the general condition of the patient. If the infection is sufficiently extensive to prevent practically a complete recovery of the kidney to normal physiological function then a nephrectomy should be made, provided the general condition of the patient is such as to make this operation fairly safe, and provided also that the other kidney secretes a reasonable amount of fairly normal urine. If the patient's condition is such as to make nephrectomy a very hazardous operation, then it is better to make nephrotomy in order to give the patient an opportunity to recover sufficiently to make nephrectomy safe at a later date. If the latter plan is followed it is best to leave the wound widely open for the purpose of securing very free drainage, and to make the nephrectomy within a few weeks after the nephrotomy has been made in order that the original wound may not heal sufficiently to necessitate extensive trauma during the second operation.

Acute Hematogenous Infection of the Kidney (Unilateral Type).—It is only within the last decade that this severe type of acute renal infection has been recognized as a distinct clinical entity. While the pathological processes are the same as in the ordinary types of blood infection, by reason of the excessive virulence of the causative organism or the low resistance of the individual, or both of these factors combined, the clinical picture is one of an acute fulminating general infection, in which the local manifestations are so slight and so generally overshadowed by the rapidly advancing toxemia that they are frequently overlooked unless a thorough and painstaking physical examination is made.

These cases are often so acute in their onset and so rapidly progressive in their septic manifestations that death may ensue before any characteristic renal or urinary symptoms are observed.

While this type of disease is rare its recognition is of the utmost importance, as it leads invariably to a fatal termination unless promptly arrested by nephrectomy.

Etiology.—Two factors are essential to the development of this condition: (1) A septic focus somewhere in the body capable of furnishing virulent organisms to the blood current; (2) a kidney whose resistance has been lowered by trauma, chronic irritation or previous disease.

The disease therefore may follow a pneumonia, typhoid fever or one

of the exanthemata; more commonly, however, it results from some local infection, as a follicular tonsillitis or some insignificant peripheral lesion, as a furuncle, carbuncle, paronychia, ulcerating tooth, middle ear or sinus infection.

From the frequency with which the colon bacillus is found in the lesions, it has been suggested that any ulcerative process of the intestine or even an obstinate constipation may act as an causative factor. As about 80 per cent. of the writer's cases have occurred in women and the great majority on the right side, the constant trauma to which a right-sided movable kidney is subjected has been suggested as probable predisposing cause.

Pathology.—While almost any pathogenic organism present in the blood current may, under favorable conditions, cause embolic lesions in the kidney, in this hyperacute type of septic nephritis the streptococcus, Bacillus typhosus or one of the virulent strains of staphylococcus are usually to be found. It is true, however, that in a few of the author's cases only colon bacilli have been demonstrated, although most observers now agree with Rovsing and Cunningham that, as a rule, the organisms of the colon group produce a less virulent infection. The author is inclined to the belief, although he has no actual proof of the assertion, that in some of his exceptionally virulent cases in which only the colon bacillus was found there may have been primarily an infection by the streptococcus, or one of the other highly virulent organisms, and that a secondary colon invasion took place in the necrotic areas, which overran the original infection and rendered isolation of the primary organism impossible.

On gross inspection at operation there is a marked edema of the perirenal fat, the kidney appears swollen, highly congested and its surface studded with small round or oval elevations, which to the examining hand give often the feeling of embedded shot beneath the capsule. When the capsule is removed these small areas of induration are found to be minute abscesses or areas of necrosis. At a later stage of the process these small lesions coalesce, forming large, irregular necrotic areas on the surface of the organ, and on cut section triangular infarcts are often seen, with their basis at the cortical border and their apices extending to the pelvis.

Fig. 102 is reproduced from a photograph of a kidney removed by Dr. Joseph A. Blake. This kidney had been damaged by previous tuberculous disease, showing clearly in the pelvis; but the lesions seen on the surface are characteristic of an acute septic blood infection and gave on culture a pure growth of streptococcus. The microscopic appearance of these lesions have already been described in a previous paragraph, and will not be repeated here.

Figs. 103, 104 and 105 are reproduced from drawings made from other fresh specimens or from photographs of kidneys removed by the author for the acute fulminating type of infection. Fig. 103 shows the early embolic stage of the process. Fig. 104 a more advanced period and Fig. 105 a still later stage, with extensive coalescence of lesions and

large areas of necrosis. This case followed an acute streptococcus tonsillitis, but at the time of the nephrectomy only a culture of the colon bacillus could be obtained.

Symptomatology.—The disease may or may not be ushered in by a chill. When present it generally indicates a severe type of infection. The initial rise of temperature is high, generally 103° to 105° F., pulse frequently 120 or above. The toxemia is marked from the first, and, with the high fever, suggests often an acute grippe, lobar pneumonia or one of the exanthemata. Then follows a more or less vague pain

FIG. 102.—Hematogenous infection, showing anterior and posterior surfaces. (Blake.)

in the abdomen or flank corresponding to the side of the lesion. Tenderness and muscular rigidity over the region of the appendix or gall-bladder lead often to error in believing one of these organs to be the seat of disease. As the urinary secretion from the infected kidney is greatly diminished, and is largely diluted by the abundant secretion from the unaffected organ, the mixed urine, when passed or drawn from the bladder, is often quite normal in appearance and the slight trace of albumin, blood and pus is often overlooked unless a more than ordinarily careful examination is made. The one pathognomonic sign present in all cases is a marked unilateral costovertebral tenderness. Cystoscopy and ureteral catetherization should be employed whenever possible in these cases. This will demonstrate

a normal bladder mucous membrane, an abundant flow of normal or slightly albuminous urine from the healthy kidney and only a few

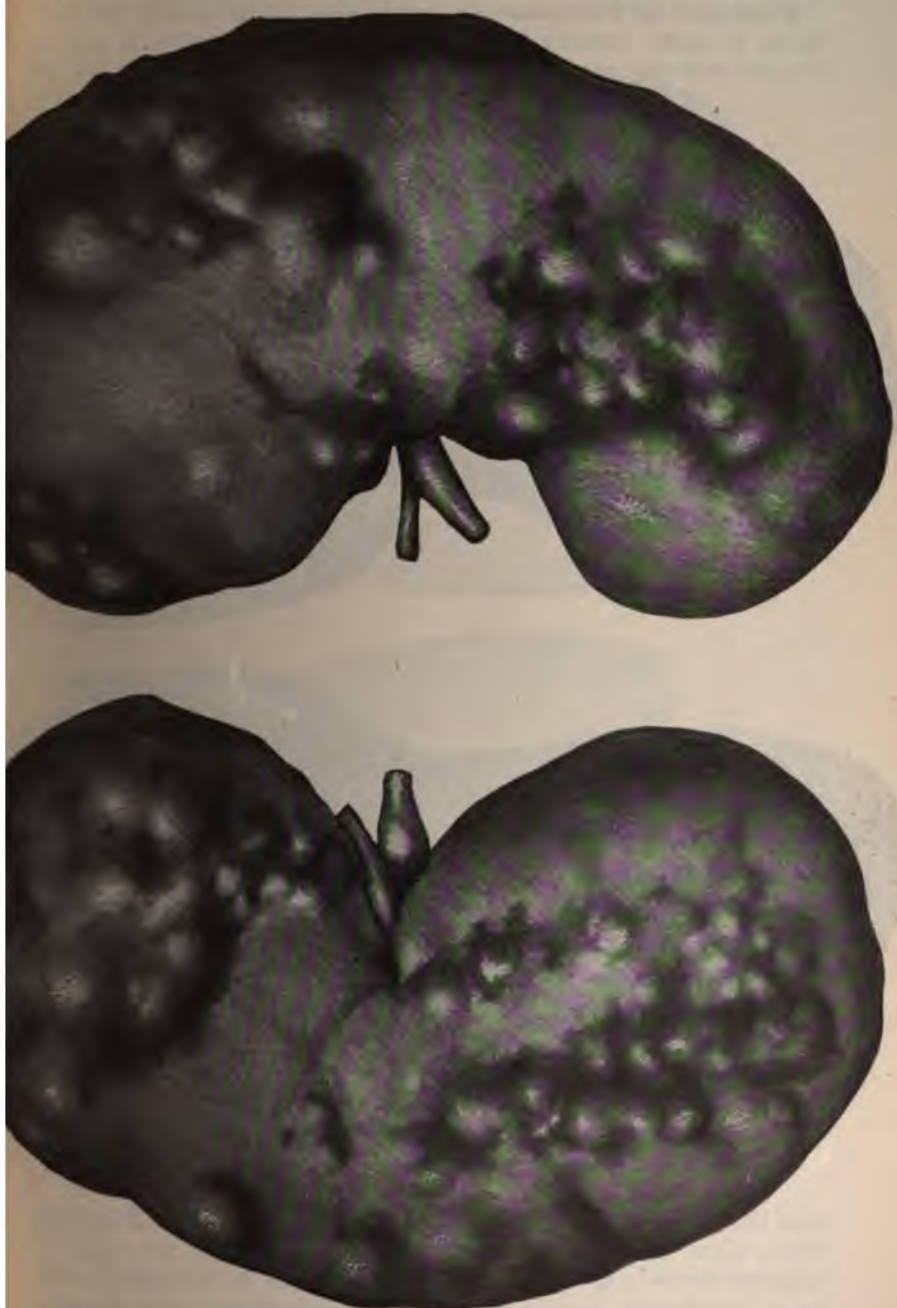


FIG. 103.—Early embolic stage: Kidney bisected, showing anterior and posterior surfaces.

drops from the affected side, showing great numbers of red and white cells and a high percentage of albumin.

Prognosis and Treatment.—In considering the prognosis and treatment in acute unilateral hematogenous renal infection it must be remembered that many degrees of virulence may be encountered, and

FIG. 104.—Later stage with moderate areas of necrosis.

that the dividing line between the true hyperacute, fulminating type, which alone is being considered in this section, and the milder or subacute types is an arbitrary one and can only be accurately drawn by an experienced surgeon who has had ample opportunity of observing the various types of this disease. In a case presenting the symp-

toms and signs already described without abatement for forty-eight hours, and with evidences of a profound and increasing toxemia, death is certain unless the condition is promptly relieved by nephrec-

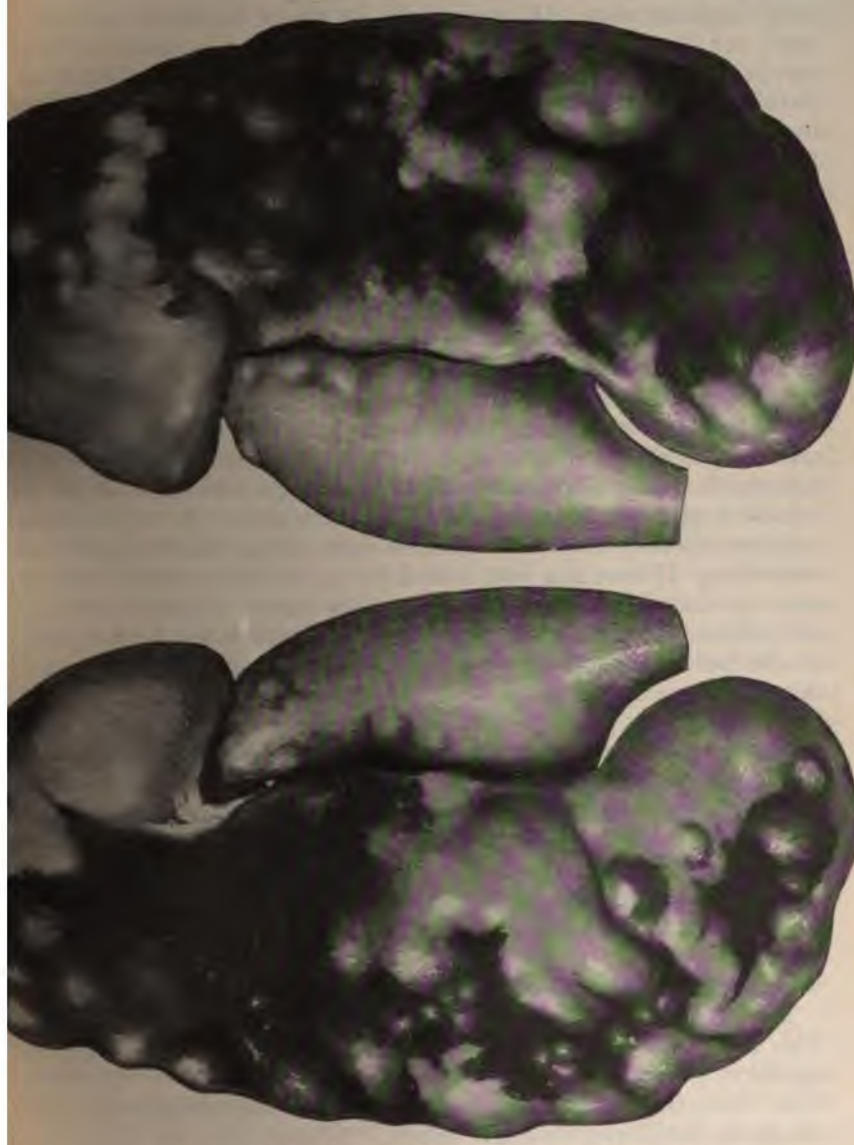


FIG. 105.—Advanced stage with extensive areas of necrosis.

tomy. To hesitate or to delay operation until a more favorable time is but to invite disaster.

The author's reason for this positive assertion in regard to treat-

ment is based upon his experience in 16 patients presenting this fulminating type of the disease. Of these 2 were untreated; both died within twelve days. Four were treated by nephrotomy and drainage. All died shortly after operation. Ten were treated by early nephrectomy. All recovered. In these desperate cases one must not be too greatly alarmed by the presence in the urine from the presumably healthy kidney of albumin and other evidences of disturbance of function, for these evidences of renal irritation are frequently due to the profound septic intoxication from the primary focus and quickly disappear after the nephrectomy.

Subacute Hematogenous Infection of the Kidney (Unilateral Type).—These cases differ from those just described only in the degree of their virulence. Often the initial chill is present, with high fever and great prostration, but the temperature begins to fall or becomes irregular after the first twenty-four to thirty-six hours. The evidences of toxemia are not as marked and are not progressive. Often the costovertebral tenderness and urinary findings are the same as in the fulminating type, but the patients do not present the same picture of profound intoxication. As the progress of these cases when untreated is almost invariably to the development of a chronic pyelonephritis, renal abscess or perinephritic suppuration, it is of the utmost importance that they be treated promptly. An early decapsulation will often relieve the intense intracapsular tension and favor resolution. If seen at a later period it may be necessary to drain one or more cortical abscesses or areas of necrosis. In one instance in the author's experience, by performing a decapsulation and draining six distinct cortical abscesses he was able to save a kidney severely damaged by a colon infection.

It occasionally happens that a portion of the kidney, as the upper or lower pole, has been hopelessly infected, while the remaining portion is practically free from grave lesions. In these cases an excision of the hopelessly diseased area may bring about a cure. Occasionally one may be mistaken in the virulence of these cases, and after decapsulation the symptoms may continue to progress. Under these circumstances one should resort to a secondary nephrectomy before the other kidney becomes permanently damaged by the septic process. In the author's experience most of these subacute cases are found to be due to an infection by the colon bacillus.

Mild Hematogenous Infection of the Kidney (Unilateral Type).—This is the type of disease usually described in text-books as *idiopathic pyelitis*. It represents the mildest type of hematogenous renal infection. Like the severer types it occurs most frequently in women and affects by preference the right kidney.

There is moderate fever, malaise and abdominal or lumbar pain on the side of the infected kidney. Later there is a moderate pyuria which may increase but is rarely associated with vesical irritability. Cystoscopy and ureteral catheterization generally indicate the lesion to be unilateral. In the early stages, when on the right side, the symptoms often suggest a subacute appendicitis, as the point of

maximum tenderness in front often is in the right iliac region. Usually it can be differentiated by a careful examination of the urine, which will always show the presence of red and white cells if the sediment is precipitated by the centrifuge. If sought for, costovertebral tenderness will always be found, and generally is more marked than in the iliac region.

This mild type of disease is occasionally encountered without spontaneous pain, and is of interest in that it accounts for certain irregular periods of temperature occurring during convalescence from some surgical operation or infectious disease. As a rule, it requires no treatment other than rest, the ingestion of an abundance of water and the use of moderate doses of urotropin.

Bilateral Hematogenous Renal Infection.—In some of the severe types of bacteremia, and occasionally in the milder types where both kidneys are damaged by chronic irritation or previous disease, bilateral renal lesions will develop. In the majority of these instances one kidney is primarily involved, and at a later period, often after the acuteness of the process has subsided, the opposite organ will be attacked. Rarely are the two kidneys infected at the same time, and a simultaneous involvement of both kidneys with an equal degree of virulence is still less frequent. The condition at best is a serious one, and in the presence of grave bilateral infection the outlook is exceedingly unfavorable. In the milder cases treatment by rest, water and urotropin is all that is required; but if the severity of the infection is such as seriously to compromise the renal function, double decapsulation is to be advised. In performing this operation, however, it is desirable to accomplish the result in the shortest possible time, and with an anesthetic which produces the minimum of renal irritation. For this reason the author advises the employment of gas-oxygen anesthesia, two operating surgeons, one assigned to each kidney, immediate postoperative renal stimulation by the intravenous infusion of normal salt solution, or proctoclysis and later the drinking of large quantities of water. In those severe cases when total urinary suppression is present, temporary vicarious elimination through the skin may be favored by hot air baths, packs and the use of diaphoretic drugs.

TERMINAL LESIONS RESULTING FROM ACUTE RENAL INFECTION.

In the following pages we will consider pyelitis, pyelonephritis, renal abscess, pyonephrosis and perinephritic suppuration, conditions which are generally described in the text-books as the classical suppurative diseases of the kidney. It must be remembered, however, that these conditions represent only the complications or terminal lesions of acute renal infection, and may arise from either the ascending or hematogenous types just described, or, in fact, from the rarer methods of infection, as by a penetrating wound or extension from a neighboring focus.

The reason why these grave destructive lesions have been so frequently encountered in the past is undoubtedly the fact that the early symptoms of the various acute forms of renal infection have been overlooked or that the treatment has been inefficient or too long delayed.

Pyelitis.—If we except those rare instances in which a suppurative pyelitis results from a penetrating wound or adjacent focus of infection, this condition is always the result of an ascending infection from the lower urinary passages.

In this connection the writer may say in passing that he has never been able to produce in animals a hematogenous pyelitis and has never seen a human specimen illustrating this type of disease. He firmly believes all of these cases, when not of ascending origin, to be mild cases of hemic infection of the kidney parenchyma in which the mucous membrane of the pelvis may or may not take part.

Etiology.—The predisposing factor in this condition is an infected state of the bladder associated with grave tenesmus or some other condition which allows a reflux of contaminated urine to enter the ureter. It may therefore arise from the backward extension of a gonorrheal infection, from infection carried to the bladder by an unclean urethral instrument or as a result of trauma of the deep urethra or bladder. It is particularly common in cases of chronic urethral stricture or prostatic hypertrophy, causing distention of the bladder and dilatation of the ureters. It may be favored by the passage of a ureteral calculus to the bladder, thus paralyzing for a time the ureteral sphincter, and it may rarely occur by the lymphatic channels as a result of deep or interstitial cystitis.

The term *calculus pyelitis* has been frequently employed and has conveyed the impression that the presence of a calculus alone in the pelvis of the kidney may give rise to a suppurative pyelitis. That this is not the case is abundantly proved by the numerous cases in which stones even of large size have been known to be present in the pelvis of the kidney for months and years without the slightest evidence of infection of the urinary passages. The presence of stone undoubtedly favors the occurrence of an hematogenous infection in the affected kidney, which eventually may extend to the pelvis. If this infection is of the mild type the parenchymatous lesions may resolve, while the irritation of the pelvic mucous membrane produced by the calculus may cause a continuance of the infection in this region or even accentuate the process. We may thus have a residual pyelitis which was of hematogenous origin. While the presence of stone in the renal pelvis does not cause a given infection of the lower urinary passages to ascend to the kidney, under favorable conditions such an infection may reach the renal pelvis and result in a condition in every respect similar to one resulting from a hematogenous infection. Faulty technic in ureteral catheterization undoubtedly gives rise to a certain number of cases of pelvic infection.

Pathology.—The organisms present in the majority of cases of pyelitis are the colon bacillus, streptococcus, staphylococcus and the

gonococcus, although cases have been reported from which the pneumococcus and other varieties have been isolated. In acute ascending pyelitis the mucous membrane of the pelvis is thickened, congested, edematous and often the seat of small areas of hemorrhage. In some cases these changes are also observed in the mucous membrane of the ureter, and in the rare cases of lymphatic extension the entire ureter and its surrounding areolar tissue may be involved in the process.

Symptoms.—While it is generally recognized that a given ascending infection from the lower urinary passages may cease at any point, the number of instances in which it stops abruptly at the renal pelvis without involving the kidney substance must be exceedingly small. In fact, some authorities, for this reason, have abandoned the use of the term pyelitis and have included all of these cases under the term pyelonephritis, believing that whenever an infection of the pelvis is of sufficient intensity to be recognized it has already extended to the renal parenchyma.

The author, however, has deemed it wise to include a consideration of pyelitis in this section, for the reason that although exceedingly rare it does exist independent of renal infection, and also for the reason that in another fairly large group of cases the pelvic lesion is the predominant one, involvement of the renal substance being so slight as to be disregarded. In the presence of an infection of the deep urethra or bladder the occurrence of fever, malaise, lumbar pain and costovertebral tenderness would strongly suggest an ascent of the infection to the renal pelvis. If cystoscopy demonstrates a flow of cloudy urine from the affected side and a clear efflux from the opposite ureter the diagnosis of a pyelitis or pyelonephritis is established. The symptoms which would weigh in favor of the former rather than the latter lesion would be the comparative mildness of the attack, the absence of high fever and evidences of toxemia and the inability to demonstrate casts or other renal elements in the urine. The term pyelitis has been rather loosely employed by certain authors, who describe certain conditions of renal infection as idiopathic pyelitis, the pyelitis of infancy, childhood or of pregnancy. As stated earlier in this section, all of these cases when arising in the absence of infection of the lower urinary passages, are typical examples of mild or moderately severe hematogenous infections of the kidney, in which the pelvic involvement is secondary.

Prognosis.—If one can be sure that the infective process is limited to renal pelvis the outlook under rational treatment should be favorable.

Treatment.—When there is reason to believe that the infection is limited to the tissues of the renal pelvis or that the parenchymatous involvement is insignificant, the treatment should consist in rest, flushing the kidneys with an abundance of drinking water and the judicious exhibition of urotropin or other urinary antiseptics. If the symptoms resist these conservative methods, irrigation of the renal pelvis through a ureteral catheter and the employment of solutions of argyrol, protargol, or even of very dilute solutions of silver

nitrate is to be recommended. It is important to guard against injury to the organ by the application of too great hydraulic pressure during these irrigations which may result in permanent harm.

Pyelonephritis.—This condition was formerly described as the *surgical kidney*, and was thought always to result from an ascending infection. More recent observations, however, have demonstrated that in perhaps the majority of instances the disease represents the terminal stage of an unrecognized or badly treated subacute hematogenous infection. Whether the condition results from an ascending or hematogenous infection the end-results are the same.

On gross inspection the kidney in the acute stage is found to be swollen, deeply congested and often surrounded by an edematous fatty capsule. On section the mucous membrane of the pelvis is thickened and injected and hemorrhagic spots and areas of ulceration may be present. In the later stages calcareous deposits may often be seen adherent to the mucosa or lying free in the cavity. The pyramids are deeply congested and often streaked with white or pale yellow lines; the cortical portion is studded with small abscesses beneath the capsule and often between the pyramids. At a later period these suppurating areas coalesce, forming larger cavities, which open by narrow orifices into the pelvis. In the early stages of the severer types the function of the kidney is entirely suspended and in some instances permanently destroyed. In the majority, however, a certain amount of renal tissue is preserved, and after the acuteness of the process has subsided a variable quantity of urine is secreted, generally of low specific gravity and deficient in solids.

Symptoms.—In all cases there are the early symptoms and signs of a subacute ascending, or blood infection of the kidney, described at length earlier in this section. As these symptoms are often overlooked or wrongly interpreted, the essential symptoms of a well-developed pyelonephritis are lumbar pain, pyuria and sepsis. The pain is of a dull, aching character, the temperature course is irregular; chills and sweats may occur, with marked tenderness in the costo-vertebral angle. The pyuria is a marked feature of all cases. Casts and renal epithelia are always present. The reaction of the urine in the hematogenous cases is generally acid; in those cases due to an ascending infection it may be alkaline. Rapid loss of flesh and progressive weakness are noticeable in the graver types. In a fair proportion of these cases calculi are present in the renal pelvis. In the hematogenous cases the lesion is generally unilateral; in the ascending type it is more often bilateral. The roentgen rays are of value in detecting calculi. Cystoscopy and ureteral catheterization will help to establish the diagnosis in doubtful cases. In addition to these symptoms the bilateral cases may exhibit signs of uremia, as a diminished output of urine, the presence of headache, stupor, dry tongue, convulsions, and coma.

Prognosis.—The prognosis in unilateral cases is, as a rule, favorable. The outlook is less promising in the bilateral cases even of moderate severity. It is exceedingly unfavorable in neglected severe unilateral

cases on account of the marked toxic changes in the opposite organ, and in all severe cases of the bilateral type.

Treatment.—As in most cases of pyelonephritis there is presumably adequate renal drainage through the ureters, except in those cases of grave and progressive sepsis, conservative measures should be given a trial. These consist in rest, milk diet, an abundance of pure drinking water and the judicious use of small doses of urotropin. If improvement does not promptly follow this line of treatment, surgical measures should be considered. If one is convinced that the disease is unilateral, nephrectomy undoubtedly offers the best chance for radical cure, provided the functional competence of the other kidney can be established. If the process involves both kidneys, with definite signs of septic absorption, the kidney presenting the most acute symptoms should be explored and a search made for any undrained or imperfectly drained collections of pus. If these are discovered they should be opened and provision made for continued drainage until the acuteness of the sepsis has subsided. Occasionally it may be necessary to explore both kidneys. The surgeon should not hesitate under these conditions, as even the gravest cases are sometimes saved by multiple operations.

Abscess of the Kidney.—While abscess formation is frequent in cases of septic pyelonephritis the tendency in those cases is toward a rapid destruction of tissue leading to rupture into the pelvis or through the capsule into the perirenal tissues. It occasionally happens, however, on account of the low virulence of the infecting organism or the high resistance of the individual, that such an abscess may progress up to a certain point, then become quiescent and remain as a closed abscess in the renal parenchyma. As a rule, these abscesses develop from the coalescence of several small foci of suppuration as a result of a mild hematogenous or ascending infection, the other lesions present in the beginning undergoing resolution. The condition may arise also from a single septic embolus or from infection of a blood clot or mass of damaged tissue resulting from trauma. As the infection in these cases is usually mild or subacute in character, after the initial symptoms have subsided they produce but little local or systemic disturbance. Always, however, there is the possibility of these again becoming more active, in which case they may rupture on the surface or more commonly into the pelvis. In the former instance a perinephritis results and in the latter a spontaneous cure may take place.

Symptoms.—These are often obscure. There may be a persistent subacute pain in the lumbar region, which is increased by any sudden movement or violent exercise. Tenderness is generally present on deep pressure. Occasionally there is moderate fever and leukocytosis, with loss of appetite and weakness. The urine may be slightly albuminous, contain a few red cells and casts, but no appreciable amount of pus unless a cystitis or residual pyelitis is present. Skilful roentgenography may rarely give evidence of an area of tissue destruction in the renal parenchyma.

Treatment.—When one is fortunate enough to make a diagnosis in one of these obscure conditions the indications for treatment are clear. Exposure of the kidney by a lumbar incision, location of the abscess by palpation or aspiration, evacuation of the pus and drainage. When these measures can be carried out, the prognosis is favorable. In rare instances of large abscesses in which the greater part of the renal tissue is destroyed or the function seriously impaired, nephrectomy is to be recommended.

Pyonephrosis.—This condition results from a combination of renal sepsis and ureteral obstruction. Two types of the disease are encountered: one in which the septic condition is primary, the obstruction occurring at a later period, the other in which the ureteral obstruction occurs first resulting in hydronephrosis, to which infection is subsequently added. This last condition is sometimes spoken of as an *infected hydronephrosis*. In the first type the primary infection may be either hematogenous or ascending, in the second the infection is usually through the blood current. If during the course of a septic pyelonephritis ureteral obstruction occurs from the presence of calculus, or a small plug of fibrin or necrotic tissue becoming lodged in the ureter; or more rarely from a kink, contracting scar, or some outside pressure, pus will collect in the pelvis and give rise to a progressively increasing pressure on the renal parenchyma. This intrarenal pressure at first causes an emptying of the bloodvessels and an anemia of the tissues, which in turn favors a more rapid destruction as a result of the septic process. The pressure also tends to increase the size of the pelvic cavity at the expense of the parenchyma. As a result the solid portion of the kidney is compressed and is the seat of numerous large and small pus cavities, often flask-shaped, opening by narrow orifices into the pelvis. In those cases, which result from an infection being added to a preëxisting hydronephrosis, the long-continued pressure has already resulted in a marked dilatation of the pelvis and a high degree of pressure atrophy of the renal substance. In extreme cases of this type the entire kidney may be converted into one large pus sac, the cortical portion being reduced to a narrow layer along the outer border often less than 2 cm. in thickness. As a rule this type of the disease presents on examination a larger tumor than the one first described.

Symptoms.—In all cases there should be the history either of a subacute renal infection or of a chronic enlargement of the kidney following on one or more typical attacks of renal colic. It often happens, however, that the primary lesion occurred long before the advent of the acute symptoms or that the patient when first seen was so prostrated with general sepsis that no clear account of the early symptoms could be elicited. When the septic kidney becomes obstructed or when the hydronephrotic kidney becomes infected there generally follows a more or less characteristic group of symptoms and signs. There is increased local pain, which may be severe, paroxysmal and radiating downward along the ureter, or steady, dull and limited to the lumbar region. Chills, or chilly sensations occur, associated

with high fever, rapid pulse and marked prostration. Marked tenderness develops in the flank; muscular rigidity is often present, and on careful bimanual palpation the sensitive renal tumor generally can be recognized. The urine rarely contains pus unless the obstruction is temporarily relieved, when it appears in large quantities. Cystoscopic examination with catheterization of the ureters shows, as a rule, no efflux from the affected kidney or only a few drops of cloudy, highly albuminous urine loaded with pus cells. There is always a marked polynuclear leukocytosis. A roentgenograph may demonstrate the presence of the obstructing calculus.

The prognosis in cases of unilateral pyonephrosis is generally favorable if rational treatment can be inaugurated before the occurrence of a fatal blood infection or too great a degree of toxic nephritis in the opposite organ.

Treatment.—This consists in nephrectomy or removal of the entire septic focus when this is practicable. When for any reason the condition of the patient will not permit the performance of a primary nephrectomy, nephrotomy, with adequate drainage, is to be recommended, to be followed by a secondary nephrectomy as soon as there is sufficient improvement in the symptoms to warrant a second operative intervention. Primary nephrectomy, however, is the operation of choice, as secondary nephrectomy undertaken many months after a severe septic involvement of a kidney is an exceedingly difficult and dangerous operation, on account of dense adhesions and the presence of the short densely infiltrated pedicle. In rare instances one may encounter a case of pyonephrosis at a sufficiently early period after the occurrence of obstruction, so that a timely ureterolithotomy with or without drainage of the renal pelvis, may bring about a cure without sacrificing the kidney.

Perinephritis (*Perinephritic Abscess*).—This is an acute suppurative inflammation of the retroperitoneal connective and adipose tissues surrounding the kidney. It may arise from infection of the kidney, from ulceration or perforation of the colon, from an upward lymphatic extension from an inflamed appendix, or from some other suppurative lesion in the neighborhood. Other unusual etiological factors may be mentioned as the introduction of infectious material as a result of a penetrating wound, or rarely a metastatic accident in the course of a general sepsis. Perhaps the most frequent renal origin of a perinephritic abscess is the condition resulting from trauma, causing a rupture of the kidney, extravasation of urine and a more or less extensive retroperitoneal hematoma. Into this damaged mass of tissue and blood clot infection may be introduced through a penetrating wound, by the possibility of the extravasated urine being infected, or by means of microörganisms reaching the traumatized tissues through the blood or lymph currents. Next in frequency comes those cases of renal infection associated with cortical abscesses, one of which may have ruptured through the capsule allowing the escape of pus or infectious material into the fatty capsule. In other cases of renal suppuration, with an unbroken capsule, the infection seems to

reach the perinephritic tissues by means of the lymphatics. In one instance the author observed the condition to arise from a gangrenous ureteritis resulting from a tightly impacted calculus. Depending upon the virulence of the infecting organism, the condition may result in an acute rapidly extending suppurative process associated with grave toxemia or the process may be a slower one and limited to the immediate vicinity of the kidney, with a preponderance of local symptoms rather than those of a grave systemic disturbance. In the severer types the pus may extend upward behind the liver to the subphrenic region or burrow downward behind the colon to the iliac fossa or pelvis.

Symptoms.—The symptoms are at first lumbar pain, fever, tenderness in the flank and on deep pressure over the hypochondriac region. If the process is a virulent one these symptoms will rapidly become accentuated and there will be chills, sweats, severe prostration and a high leukocytosis. Redness and edema of the tissues of the flank appear later and spontaneous rupture may occur. In the subacute cases the symptoms may develop slowly. The patient may keep about and only complain of lumbar pain and moderate malaise. In walking there is generally noticed a characteristic attitude, the body is bent forward and toward the affected side and the thigh is never fully extended. As the disease progresses, however, these patients finally take the bed and physical examination will reveal the presence of a tender, massive induration in the flank which can be demonstrated to lie behind the colon. Urinary examinations are generally negative, although the evidences of an infected kidney may be manifest in some cases. In the neglected cases the septic intoxication often is profound and the condition frequently complicated by a metastatic pneumonia, septic endocarditis or acute toxic degeneration of the opposite kidney. The collection of pus may be large, occasionally reaching 2 or 3 liters; and in rare instances it burrows downward to the region of the inguinal canal, and by following the spermatic cord may point at the external ring.

In the majority of instances, however, the prognosis is favorable if adequate drainage can be instituted before metastatic accidents occur.

Treatment.—This should consist in freely opening the retroperitoneal space by means of a lumbar incision, thoroughly exploring the abscess cavity, breaking down all obstructing septa and the establishment of free drainage by means of large rubber tubes. Occasionally large incisions may be necessary to insure the removal of necrotic tissue and blood clots. In rare instances it may be necessary to perform nephrectomy for the removal of a thoroughly disorganized kidney. This, if possible, should be done at the primary operation, although the condition of the patient may render it advisable to postpone the removal to a later period after partial recovery from the grave toxemia. When this is the case the secondary operation should be undertaken as soon as possible, as the adhesions resulting from an extensive perirenal suppuration quickly becomes dense and render a delayed nephrectomy an exceedingly hazardous procedure.

SURGERY OF THE KIDNEYS.

By WILLIAM F. BRAASCH, M.D.

RENAL ANOMALY.

Renal anomaly is characterized by congenital abnormality in position, outline and number. The frequent occurrence of congenital anomaly in the kidney is not generally appreciated. A review of the surgical records of the Mayo Clinic for five consecutive years shows that gross renal and ureteral anomalies are found in 36 patients. Postmortem records of the 171 consecutive autopsies made at the Clinic showed the condition in the kidney and ureter in 7 (4 per cent.) of cases. On the other hand, the proportion of occurrence of renal anomaly as evidenced by the postmortem records of general hospitals is much less. In the postmortem reports of the Middlesex General Hospital and Guys Hospital of London, Morris[1] found it occurred in but 53 cases in the course of 11,168 examinations. It is usually the pathological complication existing in the anomalous kidney or ureter which calls our attention clinically to its existence. The frequency with which such anomaly is found in a surgical clinic as compared with the postmortem records of a general hospital would, therefore, be at least partially explained by the fact that the complicating conditions usually require surgical treatment.

Fused Kidney.—Subjective Symptoms.—The fused kidney, or horseshoe kidney, may assume any of a great variety of forms and may be situated in various parts of the abdomen. Although its usual position is in the median abdomen about the level of the umbilicus, it often lies more to either side of the spine. If our attention is called to the existence of a fused kidney, it is usually because of some pathological process which causes tumor or localized pain in the median abdomen.

Unfortunately, the symptoms caused by the various pathological conditions which may appear in the fused kidney are usually confused with symptoms caused by disease in the surrounding organs. With pain referred to the median abdomen, therefore, the possibility of a fused kidney should always be considered, and a careful roentgenographic and cystoscopic examination be made in order to exclude the condition (Fig. 106).

Objective Data.—A fused kidney may frequently be palpated as a diffuse mass lying in the lower median abdomen. More often, however, it will escape detection since its position conforms to that of the vertebræ and surrounding organs without causing any evident prominence. The condition may occasionally be palpated through

[1] Surgical Diseases of the Kidney and Ureter. London, Cassell, 1901, i, 32-34.

the rectum as a retroperitoneal mass. This may be of diagnostic value particularly if the pulsation of adjacent bloodvessels can be determined. The radiographic shadow of soft tissues in the abdomen is usually too inexact to permit of accurate interpretation. Occasionally however, the outline of a median mass in a thin subject may be suggestive of fused kidney. Should the roentgenograph show a shadow of an evident renal stone in the lower median abdomen the existence of either a fused or an ectopic kidney would be indicated.

FIG. 106.—Horseshoe kidney; hydronephrosis at lower pole.

Cystoscopic Data.—The cystoscopic examination is usually the most accurate method of diagnosis. Although both meati may be found in their usual position in the trigone, one of them will often be situated in the median line. Obstruction to the ureteral catheter at the level of a pelvic mass might be suggestive of either fused or pelvic kidney. The comparative position of a leaded catheter introduced into either ureter may be seen in a roentgenogram. More exact data, however, may be obtained through pyelography by means of which

not only the relative position of the two pelves are accurately determined, but any complicating dilatation or deformity of either pelvis may also be demonstrated.

Duplication of the Pelvis.—That the normal renal pelvis may assume any of a great variety of shapes is well known. The individual calyces may be so large and situated so that they resemble separate pelves, particularly when the calyces do not unite until well beyond the hilum. When, however, there are two distinct pelves within the hilum, each having its separate calyces and ureter, the condition must be considered as an anomalous duplication of the pelvis and becomes of practical importance. For practical purposes a kidney with complete duplication of the pelvis may be considered as made up of two distinct kidneys which will permit of separation if necessary. The diagnosis of the pelvic duplication can be made accurately only by means of the cystoscope and roentgenograph combined. The finding of two separate meati on one side of the base of the bladder on cystoscopy does not necessarily indicate the existence of separate pelves, since the two ureters may unite above the bladder. Neither would two catheters introduced into separate ureters necessarily establish the existence of a duplicated pelvis, since a single pelvis may have two distinct ureters. The pylograph offers the most accurate means of determining the relative position of the pelves and the amount of renal parenchyma separating them. Further, it determines the character and extent of any pelvic deformity which may result from some pathological condition.

Solitary Kidney.—Subjective Symptoms.— Subjective symptoms are of little or no diagnostic value. The various complications which occur in the presence of congenital single kidney will cause data peculiar to themselves.

Palpation.—To be able to palpate but one kidney and to determine an evident increase in its size is at best only suggestive of a single kidney. It must be remembered that one of two normal kidneys is occasionally found considerably enlarged without apparent reason. Often it is quite impossible to differentiate hypertrophy from a large normal kidney lying low and prominent. It may be difficult to differentiate between a small renal tumor and hypertrophy. A tumor of the surrounding organs may closely simulate an enlarged kidney. If, however, on abdominal exploration the surgeon finds that one kidney is unusually large without apparent cause, the other kidney should invariably be searched for, and if present carefully examined for evidence of disease.

Cystoscopic Data.—The clinical diagnosis of the congenital absence of one kidney can be made only by means of the cystoscope, and thus the condition becomes a matter largely of cystoscopic technic. Naturally the inability to find a ureteral meatus in a markedly inflamed and contracted bladder does not necessarily indicate its congenital absence. In the hands of an experienced observer, the absence of any evidence of one meatus in a bladder which permits of a thorough cystoscopic

examination would be strong evidence of a single kidney. This may be further corroborated if on introducing a Garceau catheter into the ureter, no urine enters the bladder. Chromocystoscopy is also of value in the search for meati. Some difficulty may be encountered in differentiating clinically between acquired and congenital single kidney. When a kidney and ureter becomes functionless as occurs with a so-called autonephrectomy, the site of the former meatus often remains visible and shows evidence of inflammatory change. With a congenital single kidney the meatus is frequently situated in unusual positions, either in the median or extremely lateral base of the bladder. Close examination of the meatus may reveal hypertrophy and the peristaltic contraction will be found exaggerated. The secretion may be unusually frequent or of unusual volume. Further evidence of its hypertrophy can be obtained by means of a quantitative estimate of the renal function for which the phenolsulphonephthalein test is well adapted. A very high percentage of the dye secreted, such as usually occurs with two normal kidneys, might be indicative of the degree of compensatory hypertrophy. Of considerable interest is the pyelogram of the solitary kidney. The injected pelvis of the hypertrophied congenital kidney will usually appear considerably enlarged, but otherwise quite normal in outline. The increase in the size of the pelvis will be commensurate with the increase in parenchyma. On the other hand, with acquired single kidney, the pyelogram does not show any increase in the size of the pelvis.

Pelvic Kidney.—Anomaly in the position of the kidney may be acquired or congenital. A moderate deviation from the normal situation or a freely movable kidney is not necessarily considered a congenital anomaly. When, however, the kidney is found lying fixed in the bony pelvis or across the spine and when its bloodvessels come from adjoining vessels, such as the iliac, it must be regarded as a true congenital anomaly. Such a kidney is called an ectopic or pelvic kidney. Its clinical diagnosis is easily confused with various conditions in the surrounding organs. Subjective symptoms are usually referred to the lower abdomen and pelvis. On abdominal palpation the ectopic kidney may readily be mistaken for an appendiceal mass or a tumor of the adnexa. On rectal examination it may, in some cases, be felt as a retroperitoneal mass, and when large bloodvessels are felt with it the finding may be of value. However, the only accurate method of establishing the diagnosis clinically is by means of the cystoscope and the roentgenograph. On cystoscopy an anomalous position of the ureteral meatus may be present. The ureteral catheter can usually be introduced but a short distance. The position of a metal catheter, as shown by the roentgenograph, will localize the position of the kidney, provided the stylet can be introduced into the pelvis. More graphic and complete, however, is the pyelograph, which not alone localizes the position of the kidney but also demonstrates any anatomic peculiarities in the reno-pelvic outline. It must be remembered that the relative position of the two pelves of an

asymmetrical fused kidney, one lying in a normal position and the other lying low in the median line, might simulate the relative position of the pelves of a normal lying and ectopic kidney. Since it is the existence of some pathological condition which calls our attention to the anatomic anomaly, it is even more important that we demonstrate this complication clinically. The data obtained through the cystoscope and ureteral catheter alone will aid us materially in ascertaining the identity of the complication. The pyelogram usually is of considerable value, in determining accurately the position and extent of any pelvic distention, whether mechanical or inflammatory and to demonstrate any deformity resulting from inherent tumor. The most common complication associated with the ectopic kidney is hydronephrosis, which evidently occurs as a result of its anomalous position.

Renal Torsion.—Although the direction of the calyces with movable kidney may be unusual because of partial rotation of the kidney, complete reversal of the normal direction of the calyces and of ureteral insertion rarely complicates the ordinary movable kidney. With renal torsion the outline of the renal pelvis is completely reversed. Instead of the calyces having, in a general way, a lateral direction, they now extend toward the vertebræ. The ureter, instead of leading toward and paralleling with the vertebræ, now leaves the pelvis at the usual situation of the lateral border. The position of the kidney may cause it to be unusually prominent on abdominal palpation, and it might be easily confused with a tumor. Unless the position of the other kidney is ascertained by means of an opaque catheter or pyelogram, this condition might be confused with horseshoe kidney, which may have a similar arrangement of calyces and ureter.

The renal pelvis is situated at an unusual distance from the vertebral border. This may be explained by the lateral displacement of the entire kidney as the result of torsion. The true pelvis is unusually large, possibly as the result of partial obstruction. The calyces extend from the median border, instead of the lateral, as in the normal, while the ureter leaves the pelvis from the lateral border instead of the median.

Atrophic Kidney.—Atrophy of the kidney may be either congenital or acquired, and it may be quite impossible to differentiate the etiological factors on gross examination. Congenital atrophy is, however, a rare condition. With a marked degree of atrophy of one kidney, the other kidney is usually found hypertrophied. The discovery of hypertrophy in a kidney on abdominal exploration necessitates examination of the other side. The clinical diagnosis of an atrophic kidney may be exceedingly difficult, and when made is largely dependent on symptomatic data.

A moderate degree of atrophy could easily be overlooked in a cystoscopic examination. An evident diminution in amount of secretion on meatoscopy could easily be explained by reflex inhibition of secretion so frequently seen as the result of cystoscopic irritation. By means of a quantitative estimate we should be able to ascertain

the functional capacity more accurately than by any other means. Although a moderate degree of atrophy may be present without much evidence on cystoscopy, with marked atrophy there is various data which should call our attention to its existence. Examination of the meatus will show an atrophy of the circular muscle usually seen about the normal meatus. The meatal contraction will be slight, the secretion small in amount and seen but occasionally. The other meatus may show a corresponding compensatory increase.

Atrophy of the ureter is usually in keeping with the degree of renal atrophy. Even a small ureteral catheter may meet with difficulty in introduction as a result of atrophic reduction in the size of the ureteral lumen. The pelvis of the atrophic kidney, particularly in the congenital, may be so rudimentary that its outline in the pyelograph will be corroborative of the foregoing data.

Congenital Large Pelvis.—Occasionally in the course of routine pyelography we are astonished to find the existence of unusually large pelves in patients who have little or no objective symptoms suggestive of renal lesion, and in whom we have no other cystoscopic data indicative of mechanical obstruction in the ureter. The enlargement is usually bilateral, and is characterized by marked elongation of the true pelvis. The calyces are well formed, but are exceptionally broad at the base.. The apices and minor calyces appear normal in contradistinction to the marked changes which occur with pelvic enlargement and with hydronephrosis. The condition should not be confused with a dilatation of the pelvis and ureter which is of congenital etiology and has been called congenital atony of the renal pelvis. This latter condition is differentiated by an accompanying dilatation of the ureter throughout its extent, which does not occur with the congenital large pelvis. Further, with congenital atony, the outline of the renal pelvis is typical of hydronephrosis (Fig. 107).

Acquired Displacement.—As a result of various anatomic conditions, the kidney may become movable, and its position vary, depending on the attitude assumed by the patient. Movable kidney is commonly found in the ill-nourished, with lack of tone in the abdominal muscles and a deficiency of perirenal fat. The condition is usually accompanied by functional nervous disturbances reflected by a series of subjective symptoms that may render it difficult to identify any actual pain which might result from renal excursion. Definite objective evidence of a pathological lesion as the result of the renal excursion therefore, is often necessary before operative interference is indicated. The problem then arises, what *objective* data are of value in determining whether a movable kidney should be operated on.

The relative position and the degree of excursion of the two kidneys may be difficult to ascertain by means of palpation alone. These data, together with the course of the ureter, may be determined in the roentgenogram with the assistance of the shadow-casting catheter. Because of various technical reasons, however, the resulting roentgeno-

gram is frequently unsatisfactory in determining the exact course of the ureter and in identifying the nature of possible obstruction to the ureteral catheter. The pyelogram may offer better means not alone to show the relative position of the renal pelvis and the relation of the pelvis and ureter, but to demonstrate as well the existence and character of any pathological complication. Often a second pyelogram with the patient in the erect position may be of value in determining the comparative degree of renal excursion (Fig. 108).

FIG. 107.—Congenital large kidney pelvis.

Excursion in the position of the kidneys, even though marked, would give no objective data for surgical interference unless accompanied by evidence of mechanical dilatation in the pelvis or ureter. It would be difficult to conceive of the existence of actual constriction of the ureter to any definite degree without causing more or less dilatation of the ureter and pelvis above it. Therefore, with both pelves dystopic, even though they were situated as low as the brim of the bony pelvis, if neither of them showed in their outline any evidence of mechanical dilatation, there would be no objective data

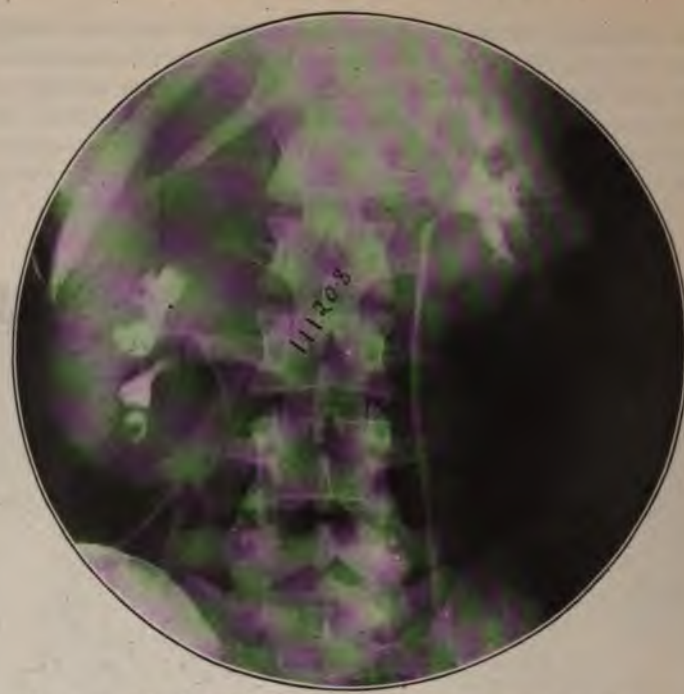


FIG. 108.—Movable kidney (dorsal position); low lying right kidney.

FIG. 109.—Movable kidney (shown in Fig. 108) in erect position; both kidneys have fallen to level of crest of ilium.

to warrant operation. Further, if the ureter showed angulation at any portion of its course, even though it were well marked and acute, unless dilatation of the ureter and pelvis existed above it, no objective data to warrant surgical interference would be present. It may be conceivable, however, that the subjective data will be so distinct as to warrant operation in selected cases. This would rarely be the case when both renal pelves are found to be extremely low.

The pelvis of the movable kidney is frequently seen to be unusually large and the calyces in particular may appear to be distended and broader than normal. Occasionally the increase in size is so great as to approach the borderline stage, where the differential diagnosis from actual hydronephrosis may be difficult. In all probability the kidney assumes certain positions, so that the interference with the urinary drainage, although not prolonged or marked, is sufficiently slight to dilate the pelvis.

Other than the above described forms of renal anomaly which include such that might be regarded of surgical importance are various forms of anomaly of lesser clinical significance such as supernumerary and aberrant renal bloodvessels, fetal lobulation, moderate degree of malposition and moderately atrophic kidneys which may result from either congenital or acquired etiological factors (Fig. 109).

Hydronephrosis.—The term, hydronephrosis, refers to a dilatation of the renal pelvis as a result of mechanical obstruction in the urinary tract. Cases of hydronephrosis may be grouped according to etiology into two classes, namely, congenital and acquired.

Congenital hydronephrosis is dependent on embryological anomaly, such as anomalous renal bloodvessels, congenital obstruction in the ureter or urethra and renal dystopia.

Acquired hydronephrosis may be the result of strictures following inflammatory or traumatic lesions, lithiasis, tumors within the urinary tract, or exerting extraneous pressure, and acquired dystopia.

The frequency with which the various etiological factors are found to occur varies with the methods of examination. Thus, according to Morris,[1] who quotes the Middlesex Hospital Reports, almost 90 per cent. of the cases of hydronephrosis found at autopsy were due to extraneous pressure of abdominal tumors. On the other hand, Israel reports but 1 of a series of 40 cases in which operation was performed for hydronephrosis as due to extraneous tumor pressure. The greatest proportion of hydronephroses are the result, either directly or indirectly, of congenital anomaly, most often an anomalous bloodvessel, which constricts the upper ureter. In a series of 116 cases of hydronephrosis recently reported in the Mayo Clinic, congenital etiological factors were found in 71 (61 per cent.). This group have certain clinical features in common, such as (1) unilateral occurrence; (2) onset in early adult age; (3) chronic intermittent course; and (4) absence of symptoms between attacks. The condition merits a distinct clinical entity and may be termed intermittent hydronephrosis.

[1] Loc cit., 1901, i, 404-406.

Subjective Symptoms.—Repeated attacks of severe pain referred to the kidney are usually the only subjective symptoms noted by the patient. In contradistinction to other forms of renal disease, there is usually a complete absence of urinary symptoms. The attacks of pain are characterized by distinct periodicity and during the intervals between attacks the patient is free from symptoms. In the later stages after the onset of secondary infection, there may be a constant dull pain. The pain is more localized to the renal area than with other lesions affecting the kidney. Frequently, however, the pain is localized in the anterior upper abdominal quadrant, and occasionally is seen in the lower abdominal quadrant, depending largely on the situation of the kidney. As a rule, the pain is not referred along the course of the ureter as distinctly as with renal and ureteral stone, but is apt to remain more localized. Hydronephrosis so large as to cause a large tumor may occasionally form without pain. A history of oliguria during an attack of abdominal pain followed by polyuria, is not of much diagnostic value, since similar phenomena are noted with neuroses.

Objective Symptoms.—With many cases of hydronephrosis, the objective symptoms are of little value. The patient usually presents himself for examination in the interval between attacks, at which time the kidney is draining and the pelvis is not distended. However, where there is more or less permanent distention of the sac, the tumor may be palpable in the upper abdominal quadrant and kidney zone. It is usually characterized by a cystic consistency and, as a rule, is not fixed. The many possibilities of error in abdominal palpation should, however, be remembered. Tumors which on palpation seem to be renal, at exploration may be found in the surrounding organs. On the other hand, tumors which on palpation appear to be located in the various extrarenal organs are frequently found at operation to involve the kidney itself. Clinical identification of abdominal pain or tumor occurring in the upper lateral abdomen by means of subjective and objective data is so uncertain that we are usually compelled to refer to cystoscopic examination. The diagnosis of hydronephrosis is largely a problem of cystoscopic technic. Not alone is the diagnosis made by this means, but the extent of the distention and the condition of the remaining kidney may also be determined. The data to be obtained on cystoscopic examination are those derived by (1) inspection, (2) ureteral catherization, (3) overdistention, and (4) pyelography.

Cystoscopic Data.—*Inspection.*—With early hydronephrosis, the data to be gained on inspection of the ureteral meatus would be of little or no value. When, however, the condition is advanced, we may expect to find atrophy of the muscle around the meatus. Further, with the decrease in renal function, there would be comparative diminution of secretion from the affected side. With secondary infection, purulent urine may be seen.

Ureteral Catheter.—Although obstruction to the ureteral catheter is usually met with, in early hydronephrosis little or no obstruction may

be noted. With advanced hydronephrosis, however, there will be obstruction in practically every case. By means of direct catheterization, the character of the obstruction may often be felt at or just below the uretero-pelvic juncture. The obstruction, even though quite definite, after more or less manipulation, usually permits the catheter to glide by.

When the catheter has entered the pelvis of the kidney, the next point of importance is the demonstration of the presence of residual urine. Its presence is revealed by a rapid flow of urine beyond the point of constriction with the usual peristaltic hesitation. The amount of residual urine will vary with the degree of distention. Care should be taken, however, to differentiate this rapid flow from the hypersecretion seen from reflex nervous irritation. The latter may be recognized when the flow is rapid from both kidneys. The residual urine with a hydronephrosis of considerable size is usually of low specific gravity and pale.

The amount of residual urine may sometimes be ascertained by means of a syringe and frequently several ounces of fluid may be withdrawn from the pelvis by this method.

The Overdistention Method.—That the capacity of the renal pelvis can be estimated by measuring the amount of fluid injected necessary to cause pain was first suggested by Kelly.[1] This has received wide recognition and is still regarded as a valuable method of diagnosis in hydronephrosis, though recently its limitations have been recognized. Its greatest value is in the diagnosis of moderate or second degree hydronephrosis—of distentions with the capacity of an ounce or more.

The fact that the patient complains that the pain caused by overdistention is similar to the original pain should not be given much reliance, but may occasionally be of value. If, however, the patient states quite definitely that the pain is different from the original the statement may be of differential value.

Pyelography.—Rendering the outline of the pelvis opaque to the *x*-ray by means of an injected opaque solution, a method known as pyelography has recently been employed to advantage. It has been proved of greatest value in the diagnosis of early hydronephrosis, but it is distinctly contra-indicated in the diagnosis of large hydronephroses.

Early Hydronephrosis.—Probably the first deviation from the normal to be noted with early hydronephrosis is flattening of the terminal irregularities seen in the normal minor calyces. Accompanying the shortening of the minor calyx there is usually broadening of the entire calyx, particularly at its base. Following soon or accompanying these changes will be noted an increase in the size of the true pelvis. With the increase in size of the pelvis, shortening or flattening of the papillæ projecting between the calyces is noted. The greatest difficulty occurs in differentiating early hydronephrosis

[1] Two cases of stricture of the ureter; two cases of hydronephrotic renal pelvis successfully treated by plicatin. Bull Johns Hopkins Hosp., 1906, xvii, 173-175.

from the large normal pelvis, since not infrequently the true pelvis of a normal kidney is of unusual size. However, if on close inspection it is seen that the terminal irregularities of the minor calyces are well preserved, and there is no broadening of the base of the calyces hydronephrosis would be definitely excluded (Fig. 110).

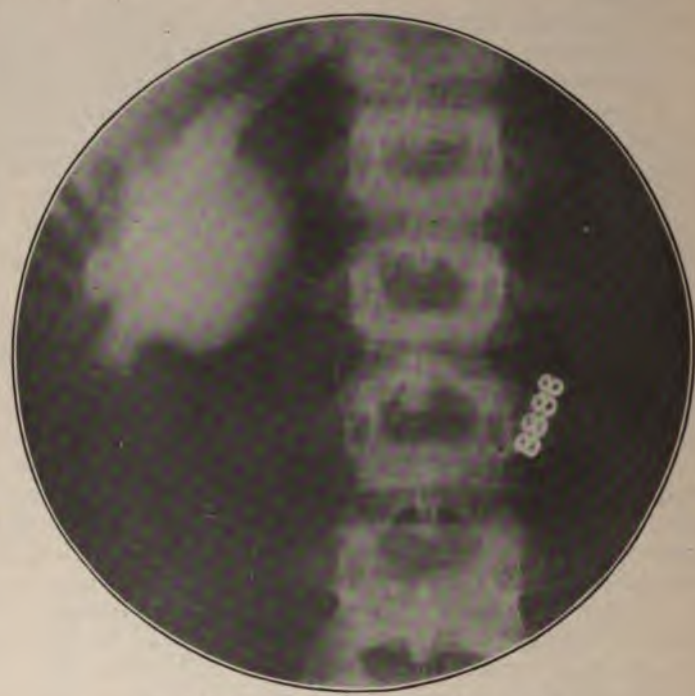


FIG. 110.—Hydronephrosis of moderate degree.

Moderate Hydronephrosis.—With increase in the size of the hydronephrosis, we first note marked broadening of the entire calyx. The terminal irregularities are to a great extent lost entirely if the calyx is fully distended. Not infrequently with the distention of the calyx there is an accompanying shortening. This may be present to such an extent that the site of the former calyx is designated by irregular indentation in the otherwise rounded contour of the true pelvis.

Accompanying these marked changes in the outline of the calyx, marked increase in the size of the true pelvis may be noted. This becomes distended with a smooth, well-rounded outline along its free border which differentiates the mechanical from the inflammatory distention. The increase in size of the true pelvis may be out of proportion to the changes in the calyces. With increase in size of the true pelvis a marked shortening of the papillæ which normally project between the calyces into the pelvis may also be noted. The papillæ may become so flattened as to be practically effaced.

Large Hydronephrosis.—The demonstration of a large hydronephrosis by means of pyelography is, as a rule, unnecessary, since its existence can usually be determined by the ordinary means of the cystoscope and ureteral catheter. However, because of difficulties in cystoscopic technic, it may occasionally be necessary to make a pyelogram in order to ascertain the exact condition. The comparatively small amount of colloidal silver solution injected will usually be greatly diluted by the residual urine in the pelvis and the exact contour of the distended pelvis may not be demonstrated in the pyelogram. A diffuse dim shadow extending over a wide area usually indicates the extent of the pelvic distention.

Urinary Data.—Microscopic examination, however, will reveal the presence of pus in varying amounts in most cases. The amount of pus varies continually and it may even be absent for a time, depending to a great extent on the drainage from the renal pelvis. The absence of pus cells, therefore, would not exclude the possibility of hydronephrosis. In several instances pus cells were not found in the mixed urine, whereas in the specimen obtained by ureteral catheterization the urine of the affected kidney showed a considerable number. Blood cells were found less often than pus cells.

Intrarenal Hydronephrosis.—The usual hydronephrosis is characterized by marked distention of the true pelvis which on surgical exploration of the kidney is seen extending from the renal cleft as an enlarged, rounded sac. Occasionally, however, the distention is largely intrarenal, and in such cases, on section of the kidney, the calyces will be found markedly distended, often reaching to the very limits of the cortex, while the distention of the true pelvis will be largely confined within the substance of the kidney. The parenchyma of the kidney is then considerably atrophied and limited in extent. It may be rather difficult to explain the intrarenal distention of the free pelvis. Frequently, however, it is due to peripyelitis with subsequent cicatricial tissue preventing the extrarenal distention.

Hematonephrosis.—A most interesting chapter in the study of hydronephrosis is the so-called bleeding hydronephrosis. While hematuria is not commonly found with hydronephrosis, occasionally it may be a prominent symptom. With the presence of marked hematuria, the clinical data are frequently confusing. The clinical differentiation of bleeding hydronephrosis from renal neoplasm may be difficult. The hematuria is usually the result of a varicose condition of the pelvic mucosa often accompanied by a chronic insidious infection. As a rule, such a hydronephrosis or hematonephrosis may be recognized by demonstrating the large amount of hemorrhagic residual urine in the pelvis. If a pyelogram is found necessary for identification, the outline of the hydronephrotic pelvis will readily be differentiated from the pelvic deformity accompanying other renal conditions which might cause hematuria. Hematuria with intermittent hydronephrosis was present in but 4 (3.4 per cent.) of the 116 cases reported from the Mayo Clinic.

Closed Hydronephrosis.—Frequently a patient may present himself because of abdominal tumor which may have appeared with little or no pain. On palpation the tumor may appear to be either cystic or firm, and may be situated so as to lead one to believe the tumor is some extrarenal organ. All urinary symptoms may be absent and the urine normal. If the tumor is caused by a closed hydronephrosis, the cystoscopic examination alone will reveal the true condition. There will be no secretion of urine from one meatus, while the secretion from the other is unusually large in amount. The catheter meets with impassable obstruction at varying distances up the ureter. The type of hydronephrosis which goes on to complete closure frequently occurs without pain. The occlusion is, as a rule, sudden with the kidney previously normal. Closed hydronephrosis is often unrecognized prior to operation and may be easily mistaken clinically for cystic gall-bladder and ovarian or mesenteric cysts. In every doubtful tumor, particularly in the upper lateral abdomen, possibility of renal involvement should be excluded even though the urinary data are negative.

INJURY TO THE KIDNEY.

Injury to the kidney may be either direct or indirect. An indirect or subparietal injury is the most common form. A slight blow over the area of the kidney or a muscular wrench may be sufficient to cause considerable rupture of the tissue of the kidney, without any evidence of external injury. Lesions of the kidney as the result of injury may be classified according to degree as: (1) Contusion which, if accompanied by subcapsular hemorrhage or a slight tear in the perinephritic tissue, may present comparatively few symptoms. (2) Laceration characterized by varying degrees of tears of the substance of the kidney, usually on the anterior and posterior surfaces. (3) Actual rupture, in which there may be pulping of the entire kidney or complete severing of various portions of the kidney.

Subjective Symptoms.—Injury to the kidney may be accompanied by shock, pain, tumor, hematuria and anuria. With simple contusion these symptoms are usually absent. With renal injury of any marked degree, there is usually a sudden manifestation of shock. This is more marked in the presence of effusion of blood either into the perinephritic tissues or the peritoneum and of intraperitoneal injury. Pain may immediately follow the injury, or may occur later with the transudation of blood into the surrounding tissues. In many instances, however, there is little or no pain referred to the area of the kidney itself.

Tumor.—Tumor may be present as a result of transudation of blood, which usually appears immedately after the injury and is later augmented by extravasation of urine. Secondary tumors may appear as the result of a complicating pyonephrosis or perinephritic abscess, though in many cases they do not occur.

Hematuria is present in most cases—from 75 to 90 per cent., accord-

ing to various observers. It is absent with subcapsular rupture and hemorrhage or with slight tears. After the initial hematuria, it may cease either because the ureter is severed, or because of clots occluding the pelvis and ureter. Although hematuria usually occurs soon after the injury, it may be slight at first and later increase in severity. When it occurs to a marked degree, symptoms from loss of blood may appear.

Anuria.—There may be considerable diminution in the amount of urine secreted immediately after the injury. Marked oliguria may persist for several days. Cases have been reported in which complete anuria was noted twenty-four hours after the injury. In case of unilateral injury this may be explained by the rupture of the kidney with laceration or severing of the ureter from one side with reflex cessation of secretion on the part of the other kidney, and the possibility of injury or disease in the other kidney.

Secondary infection is the complication mostly to be feared. This usually occurs with interference of drainage from the kidney, particularly when portions of the kidney have been completely severed. It may occur secondary to urinary extravasation in the perinephritic tissue. It is marked by chills, fever, and other evidence of infection appearing several days after the injury. Occasionally the development of a resulting pyonephrosis is insidious and may not cause well-marked symptoms until several months after the injury.

Cystoscopic Examination.—After an injury the origin of hematuria may be doubtful and a cystoscopic examination alone can ascertain its cause. Cystoscopic examination may be of value in determining the degree of the destruction of the kidney following an accident, and also in determining the functional activity of the remaining kidney. Ureteral catheterization is instrumental in determining the existence of obstruction in the ureter.

The degree of renal destruction may also be ascertained by means of pyelography and renal functional tests. In case of renal rupture directly connected with the pelvis, the opaque medium would be evident beyond the limits of the kidney. In certain cases in which the other cystoscopic data would be inconclusive as to the existence or degree of renal injury, a comparative decrease in renal function is of value.

RENAL INFECTION.

The various terms by which the different forms of renal infection are designated are based on the localization and chronicity of the disease and the resulting degree of renal destruction. Thus, if the infection predominates in the pelvis of the kidney, it is called pyelitis, and when in the cortex, it is called pyelonephritis. Acute cortical infection characterized by numerous small areas of cortical destruction is called acute septic nephritis. When the degree of tissue-necrosis becomes extensive so that cavities result, the term is called pyonephrosis.

Renal infection may be considered of hematogenous, ascending and

lymphatic origin in order of frequency. The trend of recent observations is to regard its origin as hematogenous in most instances. While a mechanical factor interfering with urinary drainage is usually present with evident ascending infection, it is regarded by many as a predisposing factor to hematogenous infection as well, in that it diminishes renal resistance. Coincident with this view is the tendency to regard renal infection as metastatic from some primary focus of infection in the body. This theory is in keeping with secondary infection occurring in various other tissues. As a result, infection involving the tonsils, teeth, nasal sinuses, genitalia, skin, etc., should all be regarded as possible foci of renal infection. The possibility of ascending infection *via* the lymphatics although evidently demonstrated by animal experiments lacks clinical corroboration.

Of interest and of etiological value is the fact that chronic renal infection occurs much more frequently in the male. In 164 cases of chronic renal infection reported from the Mayo Clinic in 1913, 112 (68 per cent.) occurred in the male. A similar proportion has been found in renal tuberculosis. It would seem that a probable anatomical factor predisposes the male to renal infection.

Pyelitis.—Infection of the renal pelvis necessarily occurs together with infection in the adjacent renal tissue and in the ureter and bladder. Although such a process would, to be exact, be termed a nephro-pyelo-ureterocystitis, we are accustomed to refer to the infection by the name of the portion of the urinary tract most extensively involved. Infection localized largely in the pelvis is termed pyelitis. Pyelitis usually remains a unilateral condition in contrast to infection of the parenchyma, which is either bilateral at the onset or soon becomes so. Although it may exist in a chronic form, it usually has a briefer course than infection predominant in the parenchyma. Acute pyelitis occurs frequently in conjunction with acute infection of the bladder. It is this condition which might clinically suggest the probability of an ascending etiology. It may occur as the result of urethral trauma as illustrated by pyelitis occurring subsequent to postnuptial trauma. Pyelitis accompanying cystitis of venereal etiology is not uncommon. With this condition the gonococcus is seldom found as the infecting organism, original Neisserian infection merely acting as a predisposing agent to a secondary infection.

Pyelitis resulting from mechanical obstruction to the urine merits separate consideration. While it is possible that the obstruction to renal drainage may lower the resistance of the kidney and thus make it subject to hematogenous infection as in the other group, the conditions are quite distinct. As a rule, when mechanical obstruction or the effect of trauma is removed, pyelitis will disappear unless considerable infection and destruction of the substance of the kidney has taken place. In the male such infection may occur as the result of hypertrophy of the prostate or stricture of the urethra. In the female the form of mechanical pyelitis most frequently seen is that accompanying pregnancy. As a rule, such infection in the female is confined

more largely to the renal pelvis than is the case with urinary obstruction in the male, and it usually clears up spontaneously or with the aid of urinary antiseptics. Occasionally, however, the process becomes chronic and extends well into the renal substance causing a varying degree of tissue destruction.

Other causes for mechanical obstruction are (1) cicatricial changes subsequent to peripelvic infection, and (2) occluding blood clots subsequent to bleeding such as occurs with pyelitis granulosa. With a considerable degree of infection in the peripelvic tissues, the pelvis and pedicle of the kidney are often found firmly bound down with dense adhesions. The upper ureter and pelvis are then dilated as the result of inflammatory changes as well as by mechanical obstruction.

Subjective Symptoms.—The onset is generally characterized by fever and malaise, with or without a chill. There is usually marked frequency in urinating and a slight hematuria. As the disease progresses the patient may complain of dull pain referred across the sacral or lumbar area. Severe pain may follow coincident mechanical obstruction to the urinary secretion and increase in intrarenal tension resulting from subsequent diffuse cortical infection or perinephritic infection. Occasionally with long standing pyelitis, the patient complains of spells of dull persistent pain with varying temperature and malaise occurring at irregular intervals. This can best be explained by sporadic acute infection of the adjacent renal parenchyma with subsequent increase of intracapsular tension.

Objective Symptoms.—During the acute stage the patient has various evidence of systemic infection. Tenderness may be present in the affected kidney area. The urine is turbid to a varying degree and may be slightly hemorrhagic. Staphylococcus aureus is more frequently the etiological bacterium than Bacillus coli. Cystoscopic examination usually demonstrates a marked degree of diffuse cystitis together with unilateral infected urine.

Medical Treatment of Pyelitis.—Although pyelitis usually disappears spontaneously, it may be aided by rest, hexamethylene and copious drinking. When pyelitis is the direct result of either trauma, mechanical obstruction to the urinary flow or insufficiency of the lower urinary tract, the cause should be removed. In the pyelitis of pregnancy, no direct interference with pregnancy is advisable, unless the infection is the cause of marked constitutional symptoms. If there is evidence of renal infection and the patient suffers from the results of mechanical obstruction to the ureter, catheterization of the ureter and lavage of the renal pelvis are indicated. Solutions of silver nitrate, commencing with 1 to 500 and increasing to 1 or 2 per cent., give the best results.

Chronic Pyelonephritis.—Subjective Symptoms.—With chronic pyelonephritis the predominant symptom of the early course is usually a variable irritability of the bladder. Although this may become severe, particularly in the case of a contracted bladder, it is usually not as severe as that accompanying tuberculosis. The patient frequently

complains of occasional dull pain referred to either loin or across the lumbar area. Severe pain is generally caused by ureteral obstruction resulting either from ureteritis or clots. Hematuria is of frequent occurrence and is either the result of marked cystitis or of eroded areas in the inflamed pelvis.

Objective Symptoms.—The general physical examination may be negative in the early stages. As the disease progresses, however, and destruction of the renal tissue results, evidence of renal insufficiency becomes apparent. Evidence of gastro-intestinal disturbance such as nausea, flatulence, anorexia, are among the early subjective symptoms of renal insufficiency and may be the first to call our attention to the existing condition. Increase in blood-pressure may be noted, together with other circulatory disturbances usually seen with nephritis. As the degree of renal insufficiency advances, the patient frequently has a peculiar "pasty" appearance.

Diagnosis.—With acute exacerbation of infection, a moderate degree of temperature and leukocytosis may be noted. The urine may appear quite clear on gross examination and only microscopic examination will show the presence of pus cells. The specific gravity is usually lowered, although in the early stages this may be but slight. A trace of albumin is generally present, together with a variable number of hyalin and granular casts. When the process involves the pelvis to an equal degree as the parenchyma, the amount of pus in the urine will be increased. Although the clinical evidence of nephritis is quite marked, examination of the urine may show only a trace of albumin, with no microscopic evidence of disease except a few pus cells.

Bacteriological Examination.—The bacteriological examination of the urine may show a variety of bacteria, chief among them being Bacillus coli and Staphylococcus aureus. Should the infection become dormant pus may be absent from the urine and the existence of infection may be determined only by bacteriological examination.

Renal Functional Tests.—Evidence of renal insufficiency obtained by clinical examination, may be corroborated by the results of renal functional tests. The greatest practical value of these tests is in determining the marked degree of renal destruction which in exceptional cases might not be ascertained by the other clinical data. There is usually a variable diminution in functional return, although in the milder forms, there will be little or no reduction.

Cystoscopic Examination.—The cystoscopic examination usually shows a variable degree of cystitis. The portion of the ureter lying in the wall of the bladder is frequently more or less dilated. Obstruction to the ureteral catheter is rather frequently met with near the ureteral meatus. It is generally found in the presence of severe cystitis and is probably the result of the edema and congestion in the wall of the bladder, rather than a primary constriction of the ureter. The specimens catheterized from the kidneys show a varying amount of pus depending largely on the degree of pelvic involvement.

Although pyelonephritis may be unilateral at the onset it soon becomes bilateral.

In but 131 of the 164 cases of chronic renal infection reported from the Mayo Clinic pus was found in the urine obtained from both kidneys by ureteral catheterization. This does not indicate, however, that the other cases were necessarily unilateral. Bilateral pyelonephritis may be present even though the urine from one kidney is microscopically negative or contains but an occasional pus cell. The amount of pus in the urine from one or both kidneys may be temporarily reduced at the time of examination because of temporary inactivity of the infection.

FIG. 111.—Mild degree of inflammatory dilatation of the pelvis and ureter.

Even though pus is absent, cultures from the urine obtained by ureteral catheterization under aseptic precautions may show the presence of infecting organisms which may be the cause of subsequent acute exacerbations. Absence of pus, therefore, after a course of treatment would not necessarily indicate a permanent cure, but merely that the process is temporarily dormant. Cicatricial changes

in the renal pelvis and ureter subsequent to previous infection, can usually be demonstrated in the pyelo-ureterogram and may be the only positive evidence of bilateral infection (Fig. 111).

Pyelographic Data.—While roentgenographic data and cystoscopic examination are of value in the diagnosis of renal infection, they may be insufficient in ascertaining the degree of renal destruction and in determining whether or not the condition is surgical. This is frequently best ascertained by means of pyelography.

The outline of the pelvis in pyelonephritis as seen in the pyelogram, may show any of the following abnormalities: (1) Dilatation of the individual calyces with little or no pelvic dilatation; (2) dilatation of the renal pelvis with little or no dilatation of the calyces; (3) dilatation of both calyces and pelvis; (4) narrowing of calyces and pelvis with dilatation of the ureter, particularly the first part. In general, the outline of an inflammatory distention is identified by its irregularity and by the fact that the changes are confined largely to the calyces, the true pelvis becoming distended only when the process is extensive. When the infectious process is chronic and predominant in the renal parenchyma, the outline of the pelvis and calyces usually appear contracted. The calyces may appear as narrow streaks radiating from the true pelvis and the ureter, particularly in its upper part, may be found dilated. In fact, the dilated ureter may often be the only pyelographic evidence of the inflammatory process. Marked dilatation of the pelvis and calyces is generally seen when the infectious process has largely involved the pelvis. The outline may be distinguished from that of early hydronephrosis in that the pelvic dilatation is more irregular and less extensive, while the calyces are relatively larger and more irregularly rounded. With the extension of the inflammatory process and destruction of the adjacent renal parenchyma, the dilatation of the pelvis and calyces may become considerable and assume the proportions of pyonephrosis. Pyelitis resulting from localized infection caused by renal stone is characterized by predominant dilatation of the calyces. In such cases, the pelvis may be but slightly enlarged with considerable irregular dilatation of the calyces. Occasionally, with a small stone lodged in the calyx, this calyx alone may be dilated to a considerable degree, while the remaining calyces show little or no change.

Differential Diagnosis.—Unilateral renal tuberculosis may occasionally be confused with unilateral pyelitis or pyelonephritis, unless a careful search is made. The delay and technical difficulties accompanying guinea-pig inoculation for tubercle bacilli, however, make more rapid diagnostic methods desirable. The absence of tubercle bacilli in the microscopic examination of the urinary sediment would not necessarily exclude tuberculosis. Although the cystoscopic examination may show changes in the bladder which are typical of tuberculosis we occasionally find unilateral pyelitis with ulceration and inflammation of the mucosa of the bladder which cannot be differentiated from that accompanying renal tuberculosis. Further-

more, both conditions may cause little or no inflammatory change in the mucosa of the bladder, so that the absence of ulceration is diagnostic of neither. Multiple strictures of the ureter when found generally accompany tuberculosis. Pyelography may be of considerable value in differentiating pyelitis and renal tuberculosis. Although the outline of the pelvis with pyelitis becomes dilated to a varying degree as shown in the pyelogram, nevertheless, it usually is well defined. With advanced renal tuberculosis and surgical pyelitis or pyonephrosis, the outline of the pelvis is irregularly dilated and may be seen connected with cortical abscesses. With early tuberculosis, however, cortical abscesses may not be visible and the pelvic changes will resemble those of pyelitis. Guinea-pig inoculation should always be employed when the etiology is left in doubt after using the various clinical methods of diagnosis.

A clinical differentiation between the comparative degree of infection in the pelvis and parenchyma may be difficult. The clinical picture of acute septic nephritis is usually easily recognized. A chronic infectious process, however, involving the parenchyma primarily and the pelvis secondarily, may be accompanied by the same subjective symptoms as occur with chronic pyelitis. As a rule, with pyelonephritis the urine is less purulent and may even at times have only an occasional pus cell. On the other hand, the urine from pyelitis may appear on cystoscopic inspection so purulent as to lead one to believe that the kidney is largely destroyed. On gross examination at exploration, only moderate changes are found in the pelvis and the evidence of parenchymatous infection is slight. In the pyelogram, the pelvic dilatation with pyelonephritis may be slight when the infection is predominant in the parenchyma.

A roentgenogram should be made as a routine procedure whenever a catheterized specimen of the urine shows pus, since renal stone may be the cause of pus in the urine without producing pain. The stone may be either the primary cause of the accompanying pyelitis or it may be secondary to pyonephritic changes of advanced pyelitis.

It should be borne in mind that gastric symptoms may be reflex from lesions of the kidney, as from disease of the gall-bladder and appendix, although possibly not so often. With pyelonephritis, particularly when well advanced and of long standing, epigastric distress and gastric symptoms are often the major and only complaints. Only a routine analysis of the urine will call our attention to possible renal infection. It should be remembered, however, that the patient may have two lesions as well as one; a coincident infection in the gall-bladder, appendix or kidney, often occurring.

Pathology of the Inflamed Pelvis and Ureter.—Whenever the renal pelvis or ureter become inflamed, a change takes place in the structure of the wall, which may be followed by dilatation. With long standing infection the pelvis and ureter may become so dilated that they are several times their normal size. On cross-section of the ureter the walls are seen to be thickened and the lumen is increased. The

pelvis is found to be irregularly enlarged, the calyces moderat dilated and the walls thickened. Microscopic examination sh connective-tissue changes in the walls with marked loss in elastici The degree of dilatation, however, is not so great as that usually s with mechanical obstruction to the ureter, nor is there such thinn of the walls. Changes in the wall of the ureter as well as the pe are usually present whenever pyelitis exists. With a moderate deg of infection the changes in the ureter may be greater than those visi in the pelvis. If an acute inflammatory process is confined to mucosa, neither ulceration nor stricture results. With erosion of mucosa resulting from tuberculosis or stone, the submucosa beco involved with consequent stricture (Fig. 112).

FIG. 112.—Inflammatory dilatation of calyces as result of tuberculosis.

Treatment.—With chronic pyelonephritis the most important me of treatment at our command are urinary antiseptics, vaccines pelvic lavage. Hexamethylenamin alone will seldom be effective curing chronic infection. It may occasionally lessen irritability the bladder.

When the use of vaccine was first advised for chronic renal in tion much was expected of it. The reports from various obser would lead us to believe that they are of little value. Occasi ally patients are observed who seem to derive some benefit fr their use. The autogenus vaccine is to be preferred.

While it would seem unreasonable to expect irrigation of the renopelvic mucosa to have much curative effect on infection in the renal parenchyma, experience has proved that such is often the case. It seems probable that the injected fluid enters the tubules, is carried into the parenchyma and thus reaches the infected areas. Solutions of silver nitrate have proved to be the medium of greatest value, according to most observers. Commencing with solutions of about 1 to 10,000 and gradually increasing to 1 or 2 per cent. without causing local irritation, has given the best results. It should be injected through large catheters, such as a Garceau, to insure introduction into the tubules. Renal lavage should, of course, be carried out only by those expert in the use of the cystoscope and ureteral catheter. In order to obtain the best results it should be given once a week for a period of six to eight weeks and then possibly every month or two for an indefinite period. The improvement, not alone in the appearance of the urine, but in the general health of many of the patients after lavage of the pelvis, is often remarkable, particularly when there is considerable inflammatory dilatation. In order, therefore, to obtain the best results in the treatment of chronic renal infection, it is best to use all three methods in conjunction, namely, urinary antiseptics, autogenous vaccines and renal lavage.

Surgical Treatment.—Although bilateral pyelonephritis is not usually regarded as amenable to surgical treatment, it occasionally becomes a distinct surgical condition when certain complications set in, *e. g.*, (1) persistent unilateral infection causing recurrent attacks of fever and weakness; (2) unilateral hemorrhagic pyelitis; (3) extensive inflammatory distention of the pelvis and destruction of renal tissue on one side, as may be seen with advanced pyelonephritis, and (4) ureteral obstruction as the result of peripelvic and peri-ureteral cicatricial changes causing intermittent colic. When any of these conditions are present, nephrectomy is indicated, even though a moderate degree of infection is found to exist in the other kidney.

Pyonephrosis.—Pyonephrosis is a term applied to a diffuse infection of the kidney which is characterized by considerable destruction of the renal substance and dilatation of the pelvis. The term is rather unfortunate in that it suggests a primary dilatation of the pelvis, although in reality the dilatation is usually secondary to an inflammatory process. According to its etiology pyonephrosis may be regarded as either primary or secondary.

When the infection originates in the renal substance, inflammatory dilatation of the pelvis and calyces and considerable destruction of the parenchyma will result. Although the infectious process may be entirely due to primary bacterial invasion, it frequently is secondary to some predisposing cause, such as stone lodged in the pelvis, calyx or cortex. Tuberculosis is also a common cause of pyonephrosis, particularly if a secondary infection complicates the primary tubercular lesion.

With secondary pyonephrosis, the inflammatory process in the pelvis and parenchyma is secondary to urinary obstruction. This often occurs with hydronephrosis, the mechanical obstruction being primary and causing the pelvic dilatation, and the secondary infection causing the tissue destruction. Such a condition has been called pyohydronephrosis.

Symptoms.—A pyonephrosis may exist during a period of many years without giving rise to any well-marked symptoms. Pain is not necessarily present, although a varying degree may be referred to the affected side. The onset may be acute and marked by fever, chills and other evidence of acute infection. The urine is usually persistently cloudy and only exceptionally hemorrhagic. The condition may be present for years without seriously incapacitating the patient and may then suddenly be the cause of a marked toxemia. It often happens that the effects of toxemic absorption are so great that the patient becomes anemic and greatly weakened. In contrast to tuberculous infection, there are more frequently slight or no urinary symptoms in spite of a marked degree of infection.

Acute pyonephrosis may be difficult to differentiate from perinephritic abscess. As a rule, there is more marked tenderness and a more diffuse mass in the kidney as the result of perinephritic abscess. Cystoscopic evidence will further differentiate between the two conditions.

Diagnosis.—*Physical Examination.*—Although there may be no apparent increase in the size of the kidney, a palpable tumor may often be present; at times this may be as large as a child's head, filling the upper lateral abdominal quadrant. The difficulties of recognizing a renal tumor on abdominal palpation have already been described. With anemia resulting from toxemia, the hemoglobin and red blood count may be remarkably low, while the leukocyte count may be either normal or considerably increased. Urinalysis will usually show a considerable amount of pus, which should always be stained for tubercle bacilli, to exclude the possibility of tuberculous infection.

Roentgenographic Examination.—Roentgen examination should always be made, since stone is so frequently the etiological factor. It usually is impossible to differentiate between a primary and secondary stone. A small, soft, cortical stone shadow with a large pyonephrosis of long standing is very often secondary.

Cystoscopic Examination.—On cystoscopic examination the bladder generally shows but a few areas of a moderate degree of inflammation, unless the pyonephrosis is associated with tuberculosis. Thick purulent urine is usually seen exuding from one ureter, and the diminished function of the kidney can be easily demonstrated.

Secondary Pyonephrosis.—The symptoms of secondary pyonephrosis are usually preceded by evidence of urinary obstruction. With ureteral obstruction and consequent intermittent hydronephrosis, typical intermittent attacks of pain will be present. These symptoms may exist for a number of years, and with the advent of secondary

renal infection, the clinical features become characteristic of pyonephrosis.

Closed Pyonephrosis.—It often happens that the ureter suddenly becomes completely obstructed with a resulting marked dilatation of the pelvis. If this takes place suddenly, there is seldom acute pain and the process may be marked only by constitutional evidence of the infection. The vesical infection, which may have been present, will improve or disappear entirely and the urine from the bladder may become quite normal when the closure becomes complete.

Circumscribed Abscess.—Circumscribed areas of renal destruction may occur secondary to localized infection, lithiasis, tuberculosis, infarction or trauma.

Abscesses occurring with stone may be due to localized interference of urinary drainage in the section of the kidney involved. The stone may be lodged at the end of the calyces and block the contributing tubules. The abscess is more often localized to the adjacent area, and should be treated as a cortical abscess and the stone removed through it.

Single cortical abscess, as a result of tuberculous infection, sometimes occurs. As a rule, the area is variably circumscribed by fibrous tissue dependent on the resisting powers of the patient. Close examination, however, of the remaining portion of the kidney may show evidence of the continuation of the infectious process into the surrounding tissues. The presence of a tuberculous abscess in the kidney even though single should require nephrectomy; drainage alone would be insufficient.

Infarcts may cause localized wedge-shaped areas of necrosis. The majority of such infarcts will probably resolve spontaneously and require no surgical interference. Occasionally, however, the tissues involved may become infected with abscess formation and necessitate drainage.

Localized abscess following hematoma, secondary to trauma, occasionally results. Although the effects of such injury may be taken care of and the damage repaired without treatment, secondary infection may set in and cause considerable tissue-necrosis and abscess-formation, requiring surgical drainage.

Perinephritic Abscess.—The exact pathology of perinephritic abscess is still undetermined and the question as to whether the abscess originates in the perirenal tissues without any primary involvement remains unanswered. Perinephritis abscess is usually referred to as primary or secondary; those originating in the perinephritic tissue being termed primary, while others originating in the kidney or some other focus are regarded as secondary. The existence of primary perinephritic infection has never been definitely established either at operation or at autopsy. Because of the large amount of evidence which demonstrates that infection of the perirenal tissues is secondary to infection in surrounding foci, it would be more logical to regard all perinephritic infection as secondary or metastatic. A

division may be made between abscesses of renal origin and those arising in other tissues. The former should be termed true perinephritic abscesses; the latter, subdiaphragmatic or retroperitoneal abscesses.

Etiology.—The etiological factors which are usually found in the order of their frequency are pyonephrosis, renal tuberculosis, nephrolithiasis, cortical abscess and traumatic rupture.

Pyonephrosis.—Inflammatory obstruction may exist for years without seriously incapacitating the patient except by occasional attacks of pain. A perinephritic abscess may suddenly complicate the situation, and the patient is then forced to seek surgical relief.

Renal Tuberculosis.—Evidence of perirenal infection with renal tuberculosis is often found at operation, and while it is more often of the sclerotic type, the formation of an abscess may occur. With perinephritic complications the pain may be continuous over a period of weeks. It is not usually so acute as with other types of renal abscesses, nor are the other symptoms so marked; the temperature and the leukocyte count being considerably lower. The prognosis of perinephritic abscess accompanying renal tuberculosis is less favorable than with other forms of perirenal infection.

Nephrolithiasis.—With stone in the kidney or ureter, the pain is usually intermittent in character. When the pain persists over a period of several days or weeks, it is the result either of continuous urinary obstruction or of perinephritic abscess. The perinephritic abscess frequently brings the patient suffering from nephrolithiasis to the surgeon, when occasional colic will not.

Cortical Abscess.—Evidence of acute localized renal infection, other than pyonephrosis, lithiasis or tuberculosis, is occasionally noted as an etiological factor. A small amount of pus will usually be found in the urine. Occasionally, however, repeated analysis of the urine fails to show any evidence of pathological elements except possibly a trace of albumin. The clinical symptoms in this group are characterized by severity, the evidence of marked infection being present in all. The leukocyte count is high, varying from 15,000 to 34,000.

Perinephritic abscess as a result of primary pyelitis or primary pyelonephritis is an exceptional occurrence.

Traumatic Perinephritis.—Perinephritic abscess may complicate a rupture of the kidney. In such cases nephrectomy is usually necessary, although when abscess follows the rupture of one pole, drainage alone may suffice.

Perinephritic Abscess without Renal Involvement.—There remains a small group of cases in which no evidence of renal infection is found on clinical examination and the etiology of which may not be ascertained at operation because of the exigencies of the cases. This type of perinephritic abscess is usually more acute and in all probability forms a comparatively large proportion of the perinephritic abscesses seen in emergency hospitals. It would seem logical to infer that a small solitary cortical or subcapsular abscess is the cause of these

unidentified perinephritic abscesses. The frequency with which hematogenous infection subsequent to some superficial lesion occurs in cases of both renal and perirenal infection would suggest their close relationship. This small proportion of perinephritic abscesses has been regarded as primary because the evidence of renal involvement ascertained by means of the data available at operation was necessarily incomplete.

Diagnosis.—In recent years only has the importance of several methods of clinical examination in the diagnosis of perinephritic abscess been realized. With the aid of these methods, the renal origin of such abscesses will be found more frequently. The diagnosis of perinephritic abscess would be inexact without the data obtained through the following methods:

1. Repeated urinalysis.
2. Bacteriological investigation of the urine catheterized from both kidneys.
3. Estimation of the comparative renal function.
4. Roentgenological examination of the urinary tract and the thorax.
5. Pyelography.

Urinalysis.—Isreal[1] has called our attention to the value of repeated examinations of the urinary sediment in determining the renal origin of perinephritic abscess. He maintained that a few red blood cells and pus cells, together with albumin and occasional casts may be found after repeated examination in practically every case of perinephritic abscess. On the other hand, it must be remembered that a few red blood cells and pus cells may be found in the urine as the result of a coincidental lesion existing in the lower urinary tract, a fact which lessons their diagnostic value. The absence of red and white blood cells in the urine would not necessarily exclude the possibility of renal origin. A practically negative urinalysis was reported in 10 of the 14 cases of unidentified perinephritic abscess. In a number of these, however, but one urinalysis was made. On the other hand, in the series of 34 cases of subdiaphragmatic abscesses of definite extrarenal origin reported by Judd,[2] red blood cells or pus cells were found in the urine in 3, the origin of these cells being in all probability in coincidental chronic urethritis, cystitis, or prostatitis which may be difficult to determine clinically.

Bacteriological Examination.—Baum[3] reported 7 cases of perinephritic abscess in all but one of which there were staphylococci in the urine. Although it has been demonstrated that bacteria, and particularly staphylococci, may pass through the kidney and be found in the urine without the existence of any renal lesion, the proportion of such cases is very small. Baum's report is one of exceptional

[1] Quoted by Baum, loc. cit.

[2] Subdiaphragmatic abscess. Journal-Lancet, 1915, xxxv, 619-623.

[3] Zur Frühdiagnose der paranephritischen Eiterung und des Nierenabszesses, Centralbl. f. Chir., 1911, xxxviii, 956.

interest and suggests a method which should be of considerable value in determining the renal origin of perinephritic abscess otherwise overlooked. The accuracy of this report is corroborated by numerous control tests and by one case in particular in which the same organism was obtained from the urine as appeared in the perinephritic tissue.

Renal Functional Test.—If a renal lesion is the cause of perinephritic abscess, a comparative diminution of functional activity from the affected kidney must follow. Although the cortical lesion may be slight, an appreciable difference should be noted between the functional output of the two kidneys. Using phenolsulphonephthalein, which lends itself admirably for this purpose, we have demonstrated a well-marked diminution of dye return from the affected side in 5 cases. (This number includes 3 cases reported in a previous article.)[1] In one of these the microscopic examination of the urine was practically negative save for a trace of albumin. In a case of retroperitoneal abscess involving the perirenal area and secondary to duodenal ulcer no difference in the functional activity of the two kidneys was found. In 1 case of chronic perinephritic abscess of probable renal origin, the difference was too slight to be of practical value.

Roentgenographic Evidence.—Roentgen examination of the urinary tract must necessarily be a preliminary step in every case of perinephritic abscess. It must be emphasized that a well-marked etiological lithiasis may be present without causing preliminary subjective symptoms. Roentgen examination of the lower thorax made in order to observe any abnormal change in the position of the diaphragm may be of considerable practical value in differential diagnosis. This is particularly true of the left side where either a perinephritic or a subdiaphragmatic abscess may be the cause of considerable displacement.

Pyelogram.—Renal infection, past or present, usually leaves some evidence of its presence in the outline of the pelvis or ureter which can be rendered visible by means of the pyelogram. Very recent infection may not, however, cause sufficient change in the pelvic outline to be of diagnostic value. The pyelogram was found of considerable value in 2 of our cases in which the clinical data suggestive of renal involvement were indefinite.

Differential Diagnosis.—It may be difficult on clinical examination to differentiate perinephritic abscess from acute septic nephritis. In the early stages of abscess development, the symptoms of the two conditions may be quite similar; both being characterized by high temperature, leukocytosis, severe pain and tenderness referred to the affected kidney area. However, with the increase in the size of the perinephritic abscess, palpation will usually determine the condition. Although the existence of an acute perinephritic abscess may easily be determined, chronic perinephritic abscess may remain unrecognized until revealed at operation.

[1] Braasch, W. F. and Thomas, G. J.: The Practical Value of Chemical Tests of Renal Function in Surgical Conditions of the Urinary Tract, Jour. Am. Med. Assn., 1915, lxiv, 104.

It may be difficult to differentiate a subdiaphragmatic or retroperitoneal abscess from true perinephritic abscess. As a rule, symptoms of the original lesion and a more general invasion of the tissues will differentiate the three conditions. The data obtained through urinalysis, cystoscopic examination, bacteriological examination, renal functional tests and the roentgenogram are often of considerable aid in differentiation.

Renal Tuberculosis.—Renal tuberculosis appears most frequently in the young adult and is characterized by persistent nocturnal as well as diurnal urinary frequency together with a variable degree of pyuria and hematuria. It is always of hematogenous origin and is usually accompanied by some evidence of tuberculous infection elsewhere in the body. As Alberran says, the disease is progressive and always ends in the complete destruction of the kidney. At its onset the disease is usually unilateral and may become bilateral after the infection has existed several years. Renal tuberculosis occurs approximately twice as often in the male as in the female.

Subjective Symptoms.—The fact that irritability of the bladder is the predominating symptom of renal tuberculosis is still not generally recognized. In a series of 203 patients operated on at the Mayo Clinic, urinary frequency was a predominant symptom in 75 per cent. It would in fact be quite logical to assume that persistent irritability of the bladder is the result of renal tuberculosis until it can be proved otherwise, rather than to place it last on the list of possible causes.

In reviewing histories of our patients, it was found that only 10 per cent. had symptoms existing six months or less and that only 30 per cent. had symptoms existing less than a year. The remaining patients had vesical symptoms, the cause of which remained unrecognized in some instances as long as ten years. Most of the patients had been treated by means of various internal medication or occasional irrigations of the bladder and attempts have been made in but a comparatively small number to determine whether or not tuberculosis was present. Although every case of irritability of the bladder is not necessarily due to renal tuberculosis, nevertheless, when it persists over a period of a month or more and is characterized by nocturnal as well as diurnal frequency, such a possibility is first to be considered. The other two cardinal symptoms of renal tuberculosis are pain and hematuria. Repeated severe pain referred to the affected kidney may be the predominating symptom and obscure the irritability of the bladder. This is usually the result of urinary retention caused by stricture in the ureter. Pain of obscure etiology is occasionally referred to the normal kidney so that the symptoms has but little localizing value. Hematuria may be the initial symptom and is frequently followed by an interval free from any other symptom. It occurs frequently in small amounts as the result of vesical ulceration and less frequently as the result of renal destruction.

Physical Examination.—In more than 75 per cent. of the cases of renal tuberculosis in the male, evidence of disease may be found in

the genitalia and should always be examined. The characteristic nodular thickening accompanying tuberculosis in the epididymis is most apparent and may attract the attention of the patient before the onset of vesical symptoms. The testicle, as a rule, is not largely involved except in advanced conditions. The seminal vesicles on one or both sides may become thickened, irregular and firm. The prostate is characterized by an asymmetrical increase in size and is usually firm and nodular. In the female the thickened ureter, which rapidly follows renal infection, may be felt through the vagina. The importance of the changes in the genitalia cannot be overestimated, and if present, together with a typical history of urinary frequency, the diagnosis is practically assured. Evidence of healed or active tuberculosis will frequently be found in other parts of the body. Routine roentgen examination of the chest in all cases of renal tuberculosis shows the presence of a varying degree of pulmonary involvement in a large proportion of cases. As a rule, such lesions are either healed or dormant. With renal tuberculosis of long standing, active pulmonary tuberculosis will not infrequently develop and prove fatal.

Renal tumor is a predominating symptom in a small percentage of cases and may be of importance in the localization of the disease. The diagnosis of closed tuberculous pyonephrosis may occasionally be made with little other evidence of the disease than the tumor. The possibility of error, however, in identifying a tumor as renal by means of palpation alone, is very great. As a rule, further corroboratory evidence is necessary.

Diagnosis.—The diagnosis of renal tuberculosis may be established in most cases by means of the comparatively simple procedure of demonstrating the presence of tubercle bacilli in the urine. It is curious to note that, although the search for tubercle bacilli in sputum is generally practised, they are comparatively seldom sought for in urine. It is particularly noteworthy since tubercle bacilli can be found in urinary sediment with practically the same technic as is employed in the examination of sputum. It has been our experience that with careful and repeated search tubercle bacillus can be found in fully 75 per cent. of the cases of renal tuberculosis. The large number of available laboratories which are now equipped for this purpose leaves no excuse for neglect in searching for tubercle bacillus. The only possibility of error in their recognition is the confusion with the smegma bacillus. This may be obviated by carefully cleansing the external genitalia, irrigating the urethra, and then removing the urine from the bladder by means of a catheter. If, however, the microscopic examination is reported negative and the symptoms are suggestive of tuberculosis, the condition may be more definitely determined by means of guinea-pig inoculation. It is best to employ at least two guinea-pigs for inoculation because of the possibility of the pig's death from infection or concurrent disease. The test has proved itself as nearly infallible as any laboratory test can be and merits more general employment. The diagnosis of urinary tuberculosis, can, therefore, be readily established and is within the reach of all.

Roentgenographic Examination.—Roentgenographic examination will not be of much value in determining changes in the renal outline due to renal tuberculosis. Occasionally, however, the areas of calcium deposits will cast shadows in the roentgenogram and are frequently indicative of the existence and degree of tuberculous involvement. The calcium deposit in caseated foci of tuberculous kidneys will often cause shadows to appear in the radiograph. The shadow is usually of three general types: (1) The cast of the caseated kidney, entirely or in part; (2) single, irregular shadows of varying size outlining the caseated center of tuberculous foci, which is the common type; (3)

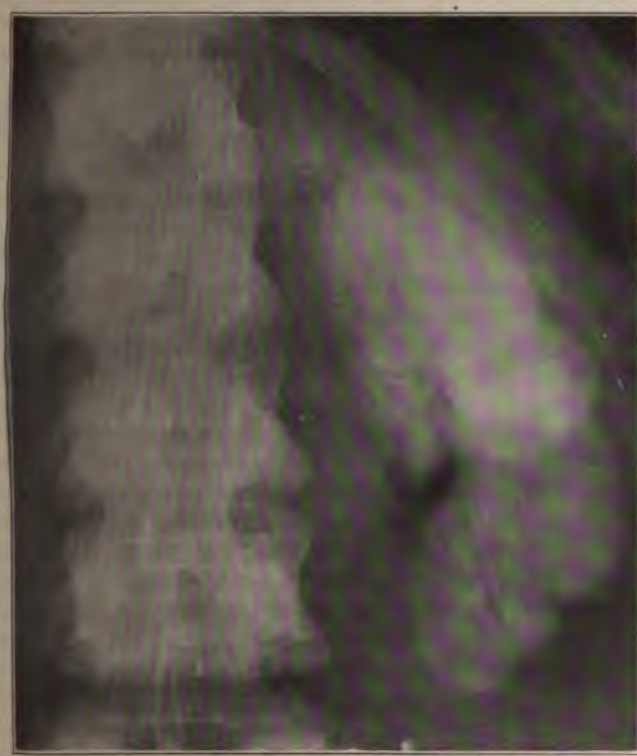


FIG. 113.—Caseated tuberculous kidney.

multiple, small, irregular shadows scattered over the kidney area. However, not all areas of caseation will cast a shadow; in fact, the majority will not. It is impossible to judge from the macroscopic characteristics whether the caseated area would cast a shadow. The shadows vary in density from a thin film to a distinct outline, and are usually more hazy and irregularly edged than the stone shadow. The diagnosis of lithiasis based on such shadows is a common clinical error (Fig. 113).

The injected roentgenogram (pyelogram) of tuberculous kidneys and

of those suspected of being tuberculous is often of considerable interest and practical value. Many tuberculous kidneys removed after an infection of several months' duration will show areas of cortical necrosis in direct communication with the renal pelvis. This can be outlined clinically in the roentgenograph of the injected cavity (thorium or colloidal silver) without any detriment to the patient. When the necrotic process is extensive the pelvis may appear markedly irregular and greatly dilated in the pyelogram. The pelvis with non-tuberculous pyelitis, on the other hand, while usually appearing moderately enlarged, is not so irregular nor will it show any cortical abscesses.

Dilatation above the constriction in the tuberculous ureter may be outlined in the injected radiogram. With a primary stricture near the bladder the resulting hydro-ureter may simulate that resulting from a congenital or traumatic obstruction.

Differential Diagnosis.—Localization of the disease is the next and very important step to complete our diagnosis. This is entirely a question of cystoscopic technic, and it is frequently a most difficult one even in the hands of an experienced observer. Without going into the details of the cystoscopic picture of the tuberculous bladder, suffice to say that while it is not necessarily pathognomonic, particularly in the early stages, the condition can, nevertheless, frequently be recognized by an experienced observer. By means of the cystoscope we are able to determine (1) the degree and character of infection in the bladder; (2) whether infection is secondary to the kidney or to the epididymis and prostate; (3) which kidney is involved and the degree of involvement; (4) to a certain extent the functional capacity of the remaining kidney; and (5) whether both kidneys are involved.

Pyelonephritis.—The clinical data with pyelitis or pyelonephritis and renal tuberculosis may be quite similar and their differential diagnosis difficult. The absence of tubercle bacilli in the urinary sediment does not necessarily exclude the possibility of tubercle bacilli. The cystoscopic data may be practically the same, since both conditions may have similar degrees of cystitis. With pyelonephritis the infection is usually bilateral and both kidneys are about equally involved. With tuberculosis the condition is more often unilateral and a functional test will show more or less diminution of function from one kidney. The pyelogram may be of value in demonstrating the dilatation of the pelvis or ureter, typical or tuberculosis. If, however, no positive differential data are available, practically the only way to differentiate between the two conditions would be by means of guinea-pig inoculation.

Bilateral Tuberculosis.—Although some observers have regarded bilateral renal tuberculosis as usually occurring simultaneously, in most of the series of cases reported from the Mayo Clinic, the second kidney became infected several years after the first one.

Of the cases diagnosed as bilateral tuberculosis the majority gave a history of evident renal infection dating back from two to ten years. The course of the second infection may often be traced by the history

of a comparatively recent exacerbation of vesical symptoms and pronounced general weakness occurring several years after the first infection. This is, furthermore, often borne out at operation when bilateral exploration not infrequently reveals an old abscessed kidney on one side and a recent small focus in the other. The danger of subsequent infection in the second kidney should be regarded as an urgent argument for early operation. Irritability of the bladder is frequently diminished in advanced bilateral involvement. Cystoscopic examination will then often show the mucosa of the bladder to be necrotic and covered with a thick, purulent exudate, rendering it impossible to see the ureteral meatuses. Pulmonary infection is a frequent terminal complication of bilateral disease. The symptoms of renal insufficiency accompanying bilateral involvement are quite different from those usually accompanying the insufficiency of nephritis; emaciation, weakness, nausea and vomiting are the usual symptoms observed, while edema of the extremities is seldom seen and ophthalmoscopic examination is usually negative.

Closed Tuberculous Pyonephrosis.—When the ureteral constriction becomes so great as to prevent any infecting secretion from reaching the bladder, the process is called "autonephrectomy." In such cases the bladder may recover entirely, although usually a small amount of the secretion will find its way into the bladder so as to reinfect it sporadically to a varying degree. The vesical symptoms are then often obscured by those of abdominal pain or tumor, while the absence of pus or tubercle bacilli in the urine may further mislead one.

Cystoscopic examination must determine the absence of secretion from the affected side and will usually reveal several areas of ulceration often situated on the bladder roof. The roentgenogram may also be of corroborative value by demonstrating the shadows which are often cast by the calcium deposit in the caseated areas.

Non-surgical Treatment.—While it may be true that there may be an occasional spontaneous recovery from incipient renal tuberculosis, it occurs so rarely that the possibility should be disregarded. The various medical measures by means of which renal tuberculosis has been claimed to be cured are climatic, heliotherapy and tuberculin. Within the last few years we have observed a number of patients who have been treated by means of tuberculin without permanent benefit. The experience of Wildbolz[1] as reported in the German Congress of Urology in the use of non-surgical methods is conclusive. He reported a careful study of 316 cases of renal tuberculosis treated in Switzerland by various Swiss physicians, by methods other than surgical. His summary is of exceptional value and quite conclusive, since Switzerland is supposed to have climatic conditions favorable for the treatment of tuberculosis, and contains many sanatoria for that purpose. All his patients had careful bacteriological and many of them had

[1] Dauererfolge bei Nephrektomie wegen Tuberkulose, Verhandl. d. deutsch. Gesellsch. f. Urol., 1912, iii, 27-74.

cystoscopic examinations. Postmortem records were available in many. Of the number he reported 70 per cent. died, 60 per cent. in less than five years. Most of them died of complications resulting from infection in the urinary tract. Only 10 per cent. were alive more than five years after the beginning of the disease; in only 5 per cent. had all symptoms ceased over five years; and but 1 patient was positively well in every respect. These observations agree with those made at the Mayo Clinic and prove quite conclusively that permanent recovery from renal tuberculosis without surgical removal of the diseased kidney is exceptional and not to be relied upon.

RENAL LITHIASIS.

In a series of 512 patients operated on at the Mayo Clinic renal lithiasis occurred in the male twice as often as in the female. This proportion is in keeping with the incidence of renal infection and may be regarded as strong evidence of the bacterial origin of lithiasis. Renal lithiasis usually occurs in the adult between the ages of twenty and sixty years, and most often from twenty-five to forty years. Both kidneys are affected with equal frequency. Stone occurs bilaterally in about 12 per cent. of the cases. In the order of their occurrence the most common types of stone are oxalates, phosphates and uric acid. The various ingredients are usually mixed although one element may be predominant.

Subjective Symptoms.—The subjective symptoms occurring most frequently with renal lithiasis are pain, hematuria and evidence of renal infection or insufficiency.

Pain.—Pain caused by a stone in the kidney is the result of increase in intrarenal tension caused by either the retention of renal secretion or by renal infection. The degree of pain is not dependent on the size of the stone, but on the extent to which it obstructs urinary secretion. Typical renal colic occurs with renal lithiasis in less than two-thirds of the cases. The pain may be referred to various parts of the abdomen, varies markedly in degree and is frequently absent. In a review of 251 patients operated on at the Mayo Clinic for renal stone, the pain was referred to the affected kidney area with anterior and downward radiation in 117 (46 per cent.) cases; to the anterior upper lateral abdomen with posterior radiation in 30 (12 per cent.) patients; to the lower abdomen, with upward and lateral radiation, suggestive of appendiceal disease in 32 (13 per cent.) patients, and in 26 (10 per cent.) patients, the pain was general over the abdomen. The pain was referred to both sides in 56 (22 per cent.) patients and was absent or very slight in 21 (8 per cent.) patients. It will thus be seen that the radiation of pain accompanying renal lithiasis varies considerably and may be very confusing in the identification and localization of the disease. A roentgenogram of the entire urinary tract should be made in every case of unidentified abdominal pain. Fol-

lowing this rule, one is frequently surprised to find the presence of either renal or ureteral lithiasis, bilateral as well as unilateral.

Hematuria.—Although hematuria has been regarded as a fairly constant symptom with renal lithiasis, it was noted by only 141 (56 per cent.) of the 251 patients. While hematuria most often occurs with pain, occasionally it appears in the interval. It is rarely profuse, persists but a few hours, and is frequently brought on by unusual exercise. Hematuria may be the only symptom. Therefore, in every case of hematuria a complete roentgenographic examination should be made regardless of the presence of pain.

Renal Insufficiency.—Lithiasis may exist without causing any subjective symptoms until the kidney tissue becomes largely diseased. Evidence of renal insufficiency will then be manifest, and gastric symptoms, and general weakness may cause the patient to seek medical counsel. This occurs particularly often with bilateral nephrolithiasis. Attention then is often directed to a possible surgical condition by the presence of persistent pus in the urine. A roentgenographic examination of the urinary tract is indicated in the presence of indefinite gastric symptoms and pyuria. Circulatory changes that usually accompany toxic nephritis are seldom seen with this condition.

Objective Data.—*Tumor.*—Physical examination in cases of renal stone is, as a rule, comparatively unimportant. However, a pyonephrosis of considerable size may develop, particularly if the stone obstructs the renal pelvis, the patient often being unaware of the existence of the tumor. Chronic absorption of toxins from pyonephrosis will frequently cause symptoms of toxemia, such as anemia, weight loss, anorexia, etc. The patient may then have a peculiar yellowish color of the skin and other evidences of toxic absorption.

Urinalysis.—Blood was found microscopically in the urine of 228 (91 per cent.) of the total number of patients. It is found so frequently in the urine in the course of routine examination as a result of various causes that its presence cannot be regarded as much diagnostic value. Although the presence of red blood cells in the urine should require a thorough roentgenographic examination of the urinary tract, it should not influence us in the interpretation of a doubtful roentgenographic shadow. Microscopic pus to a varying degree was present in the urine in 232 (93 per cent.) patients. It is apparent, therefore, that the absence of microscopic pus or blood, while unusual with renal stone, cannot be relied on to exclude it. The presence of crystals in the urine is of little exact diagnostic value. Showers of the various crystals are frequently found in the urine when there is no stone. On the other hand, stone is frequently present without crystals being found in the urine.

Estimate of Renal Function.—It is often quite difficult to estimate the functional capacity of a kidney containing a stone and to determine whether lithotomy or nephrectomy is indicated. When on cystoscopic examination, the urine from the affected kidney appears so purulent that it is creamy and diminished in amount, one may

infer that but comparatively little renal function remains. On the other hand, the urine from the affected side may appear comparatively clear on cystoscopic examination, and at operation widespread destruction of cortical tissue may necessitate nephrectomy. Quite frequently on meatoscopy, urine will not come from the ureters on the affected side for as long as ten or fifteen minutes, and one might easily interpret this evident cessation of secretion as due to renal destruction. Ineffectual peristalsis of the meatus or continuous contraction may be seen during this period, which is probably best explained by reflex contraction from cystoscopic irritation in a ureter previously rendered irritable by the stone. The estimation of renal function in the presence of stone by means of chemical tests, while frequently of value, may be uncertain and erroneous. The fundamental weakness of chemical renal functional tests lies in the fact that the functional activity of the affected kidney may be ascertained at the time of examination, but not its functional capacity when normal conditions

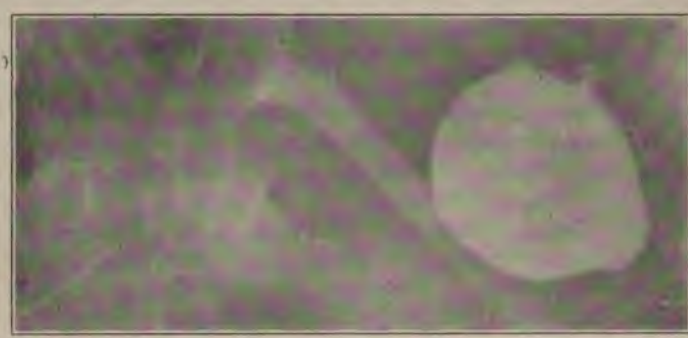


FIG. 114.—Large round kidney stone. Type usually found in pelvis of kidney.

are restored. A stone lodged in the kidney will usually cause marked diminution of functional activity, as may be demonstrated with phenolsulphonephthalein. Renal stone will very often cause a marked reduction in the amount of the dye returned from the affected kidney as compared with that of the other kidney. This might lead one to infer that but little of the kidney's function remained, and that nephrectomy was indicated. In operating on these patients, the kidney is often found but slightly diseased, and after operation the normal functional activity returns. However, the functional test may be of considerable value in certain conditions. In cases in which there is a total absence or mere trace of phthalein return from the affected kidney, a nephrectomy is usually indicated, even though the urine appears comparatively clear. Again, in cases in which the question arose as to whether or not a shadow was intrarenal, a marked comparative diminution of functional activity on the side in question would be suggestive of renal involvement. Although in the majority of cases of stones in the kidney, more or less comparative diminution in functional activity results occasionally, no material difference will

be found between the two sides. Equal functional return would, therefore, not exclude the possibility of stone. With bilateral nephrolithiasis, the comparative estimate of renal function may sometimes be difficult without a functional test. As an aid to diagnosis, therefore, the functional test is of considerable value; as an aid to prognosis, it is limited (Fig. 114).

Roentgenographic Examination.—The most valuable method at our command in the diagnosis of renal lithiasis is the roentgenogram Practractically every stone in the kidney which may be regarded as surgical, will cast a shadow in the roentgenogram if the roentgenographic technic is correct. Unfortunately, there may be many forms of calcareous deposit in the abdomen which will also cast shadows in the roentgenogram similar to those occurring with lithiasis. A larger percentage of error in roentgenographic diagnosis is dependent on incorrect interpretation than on the absence of a shadow. While the majority of extrarenal shadows can be recognized from their position, shape and general characteristics, a large proportion will require further data to identify them. Such data may be acquired either by means of cystoscopic examination alone or in coöperation with r.œntgenography. Among the various conditions which most frequently give rise to shadows in the kidney area simulating renal lithiasis are: gall-stones, calcareous glands, and calcareous foci of renal tuberculosis. Shadows caused by gall-stones occur frequently enough to be considered in the interpretation of all shadows appearing in the right upper quadrant. Gall-stone shadows will be differentiated by the following: High location, peculiarities of the shadow which are characterized by a more clearly defined periphery than center, and multiple occurrence with comparative regularity in arrangement. However, the gall-stone shadow may assume a great variety of shapes and characters and may frequently simulate closely the renal stone shadow. It may lie in the region of the kidney, and should there be a coincidental infection of the urinary tract, the diagnosis might be exceedingly difficult. On the other hand, renal stone may quite frequently be seen lying well above the twelfth or even the eleventh rib, in the usual gall-bladder area. Further, the renal stone shadow may assume characteristics very similar to those of the gall-stone. In short, the shadows cast in the roentgenogram by the gall-stone and by the renal stone may be identical in position and character. The pyelogram is usually the best and very often the only method by which the gall-stone may be identified. The shadows caused by calcareous deposits, particularly when occurring in tuberculous foci, are frequently recognizable, chiefly because of their irregularity and haziness. As often, however, cystoscopic and even pyelographic data will be found necessary for their identification.

When the consistency of the stone is soft, in the presence of a large amount of abdominal tissue and with imperfect roentgenographic technic, renal stone may not be detected in the roentgenogram. In such cases the pyelogram occasionally demonstrates the changes in the pelvic outline which usually accompany renal stone, and with this

evidence further efforts directed toward the roentgenographic demonstration of the stone may be successful. Further, it has been found that solutions of colloidal silver will coat the surface of a stone to such a degree that it will cast a shadow. If a roentgenogram is made on the day following a pyelogram, the outline of a stone overlooked in a previous roentgenogram may be rendered visible by the coating of silver.

Shadow Identification.—Most of the shadows in the kidney area may be identified by their contour, character and position. However, the shadow of the renal stone is frequently atypical in form, character and position. Moreover, extrarenal conditions may be the cause of shadows that are readily confused with renal stone. Often in the course of routine roentgenographic examination, shadows are suggestive of renal stone and yet the clinical data either subjective or objective, would negative its existence. Data other than that derived from the ordinary reontgenogram will frequently be necessary for identification. In such cases the data obtained by means of cystoscopic inspection and the ureteral catheter are often sufficient for the identification of the stone. Comparative diminution in renal function as ascertained by phthaline may also be of diagnostic value. Certain shadows can be identified only by means of pyelography. However, the latter method should not be employed as a routine procedure, but used only when interpretation is doubtful or when exact localization is desirable. By these various methods unnecessary surgical explorations and failures in recent years have been reduced to a minimum.

The pyelographic data which will enable us to determine whether a doubtful shadow is extrarenal or intrarenal are as follows: (1) The distance separating the shadow from the pelvic outline; (2) the exact relation of the shadow to the pelvic outline; (3) the presence of pathological changes in the pelvic outline.

When the distance separating the shadow in question from the pelvic outline is three or four inches, the extrarenal nature of the shadow is demonstrated. Should the extrarenal shadow be situated adjacent to the outline of the pelvis, it might easily be confused with a cortical stone. By this means unnecessary surgical explorations and failures to find renal stone have in recent years been reduced to a minimum. The majority of stones in the kidney that are large enough to be visible in the reontgenogram, will cause recognizable changes in the reno-pelvic outline. Abnormality in outline in the presence of renal stone is consequent to either mechanical obstruction or to inflammatory changes in the tissues. Dilatation of the renal pelvis consequent to stone in the pelvis, is not, as a rule, extensive and is usually confined largely to the individual calyces. These changes will vary from that of moderate pyelitis to the marked deformity resulting from pyonephrosis. Often the changes in pelvic outline are consequent to both mechanical and inflammatory influences. Occasionally the inflammation and dilatation in the ureter may be more pronounced than that in the pelvis and may be of considerable value in determining the intrarenal situation of a doubtful shadow.

Shadow Localization.—When a shadow in the reontgenogram is small and the clinical data are uncertain, the shadow requires not only identification, but localization as well. It is of value to the surgeon to ascertain the exact location of the stone as accurately as possible prior to operation. In bringing the kidney into the field of operation it usually becomes congested and enlarged so that searching for a small stone may be exceedingly difficult and often fruitless. Localization of the stone shadow in the original reontgenogram is frequently possible when the outline of the kidney is distinct, and when its location corresponds with the usual position of the renal pelvis. However, should the shadow be situated toward either pole of the outline of the kidney or at one side of its median portion, it would be difficult to locate the stone. Moreover, it is often impossible to obtain a definite outline of the kidney because of the technical difficulties involved. Further, the outline of extrarenal organs occasionally simulates that of the kidney. By outlining the renal pelvis in a pyelogram and then comparing the position of the shadow with that of the pelvic outline, the stone can be localized more accurately than in the ordinary roentgenogram. The main problem in the localization of the stone is to determine whether it is situated in the true pelvis, in a calyx, or in the cortex.

General Data.—Stone situated at the uretero-pelvic juncture will more often cause pain than stone situated elsewhere. Triangular-shaped stones are usually found at the uretero-pelvic juncture. The branched stone causes less pain, as a rule, than other types. A branched stone will be found the most difficult to remove, and when of considerable size will more often necessitate nephrectomy. Recurrence is more frequent with a branched stone than with any of the other forms. The large round stone in the pelvis of the kidney is less subject to recurrence than any other form. It is comparatively seldom that a stone is found at the side of the calyx, always at the end. The stone may be found lying partially in the calyx and partially in the cortical substance. When the stone is thus situated it may have to be treated as a cortical stone and removed through the cortex. A cortical stone is more likely to recur than a pelvic stone unless the patient drinks an abundance of distilled water daily during the remainder of his life. A certain degree of concentration of urine is necessary for the crystalization of urinary salts without which stones cannot be formed and this concentration can be prevented by regularly drinking an abundance of distilled water. They are frequently the cause of considerable inflammatory destruction in the surrounding tissue. Stones occurring secondarily to a primary inflammatory process are always cortical stones.

RENAL TUMORS.

Renal tumors may be classified according to their degree of malignancy as benign and malignant and according to their situation as involving (*a*) the parenchyma, (*b*) the pelvis and (*c*) the capsule.

Benign tumors are of comparatively infrequent occurrence and only occasionally are the cause of clinical symptoms. Adenoma, fibroma, myoma, chondroma, osteoma, angioma and gummata have been variously reported. Small adenoma are of rather frequent occurrence but rarely cause any symptoms. Papillocystadenomata, although usually malignant have been regarded as benign. Angioma of the papillæ first described by Fenwick is a comparatively unusual condition and is characterized clinically by intermittent symptomless hematuria. Renal syphilis is of rare occurrence and its diagnosis can be made only on exploration and examination of tissue. A positive Wassermann with hematuria and tumor are insufficient data.

Malignant tumors of the kidney may be classified according to their histologic structures, as hypernephroma (mesothelioma), sarcoma, carcinoma and embryoma. Clinical differentiation according to the above histologic classification cannot usually be made prior to exploration.

Subjective Symptoms.—The cardinal symptoms of renal tumor are hematuria, tumor and pain. Given a clinical picture of a palpable tumor in the region of the kidney, hematuria, persistent pain referred to the region of the tumor and the general symptoms of malignancy, the diagnosis of renal tumor will usually be correct. As a rule, these complete data will be found only in about a third of the patients. More frequently there will be two or three symptoms and in a considerable proportion of cases but one symptom may be present. The clinical diagnosis is most often made from but one or two of the cardinal symptoms.

Hematuria.—Probably the most important symptom with malignant renal tumor is hematuria. In a series of 83 patients with renal tumor operated on at the Mayo Clinic, hematuria was observed by 53 (64 per cent.) of the patients. It was referred to as a primary symptom by 39 (36 per cent.), and the only symptom by 10 (12 per cent.). Gross blood was found in the urine at the time of examination in 33 (40 per cent.). Hematuria as a subjective symptom, may be of doubtful value. Occasional hematuria may be disregarded or forgotten and the female patient may believe it to be of menstrual origin. Again, patients often give a history of hematuria, which may have originated from some passing condition in the bladder or urethra. As a rule hematuria accompanying tumor occurs in large amounts and is of comparatively short duration, lasting from one day to a week.

Pain.—When pain results from renal tumor, it is caused either by the pressure of the tumor on the surrounding nerve trunks or by the increase in intrarenal tension resulting from interference with urinary drainage. When caused by the pressure, the pain may be referred to various parts of the upper abdomen and back and is consequently often misleading. Abdominal pain to a varying degree was complained of by 68 (82 per cent.) of the 83 patients. It was given as a primary symptom by 27 (32 per cent.), and as the only symptom by 14 (17 per cent.). Pain was referred to: (*a*) The affected kidney in

30 (74 per cent.) of the patients; (*b*) to both kidneys in 4 (6 per cent.); (*c*) across the back in 11 (17 per cent.); (*d*) diffuse and of no localizing value in 8 (12 per cent.). With several patients the pain referred to the affected kidney occurred with hematuria only and in all probability resulted from the obstruction in the ureter caused by blood clots.

Circulatory Disturbance.—Evidence of circulatory disturbance is frequently found with hypernephroma (mesothelioma). In fact, it is observed so often as to suggest the presence of a vasomotor-dilating toxin. Dilatation of the superficial bloodvessels may be apparent in the face as well as in the bladder, scrotum and in hemorrhoids. The dilated veins in the face sometimes cause a flushed congested appearance, which is almost pathognomonic. Dilated veins in the scrotum or varicocele occur more commonly with hypernephroma than is generally recognized. A history of a varicocele of recent onset in a patient of forty or more years renders an unidentified hematuria or tumor very suggestive of hypernephroma. Varicocele should always be searched for when renal tumor is suspected. In 30 male patients with renal tumor observed at the Mayo Clinic, the condition was found in 9 (30 per cent.). Hemorrhoids of recent appearance are frequently noted. Dilated bloodvessels in the bladder may occasionally be seen in a cystoscopic examination. Cardiac dilatation is a rather common late symptom and often may be too advanced to permit operation. Although similar vascular dilatation may occur with various extrarenal tumors, it may then be explained by mechanical pressure. The peculiar frequency, however, with which vascular dilatation is found coincident with renal tumor must be explained by causes other than mechanical.

Tumors.—Palpation of a tumor in the kidney area is often of uncertain diagnostic value, even when aided by percussion and bowel inflation and presents many possibilities for error. The following data in the palpation of the kidney may be of practical value:

1. Tumors of the surrounding organs may simulate renal tumor in position, form and consistency, so that it is quite impossible to differentiate them by means of palpation alone.

2. Renal tumor, particularly when involving the lower pole, may extend irregularly toward the median abdomen or down into the pelvis so as to simulate tumor of the various extrarenal organs.

3. Renal tumor may be very uncertain on palpation (*a*) when the kidney lies high, (*b*) when the tumor involves the upper pole, and (*c*) when it occurs in a fat abdomen. Frequently the tumor is found astonishingly large at operation when, on palpation, an enlargement could not be determined or was considered questionable.

4. Kidneys otherwise normal are occasionally found so large that they simulate tumor on palpation. This hypertrophy may occur without apparent reason or as the result of diminished function in the other kidney.

5. Low-lying large kidneys in thin patients may simulate moderate tumor enlargement.

The tumor with renal neoplasm is generally firm on abdominal palpation and is more or less irregular. In the majority of patients coming to operation, it appears to be fixed or but slightly movable. When it is definitely immovable, the prognosis is necessarily rendered less favorable, and may even contra-indicate operation. The absence of a palpable renal tumor in the presence of hematuria, loss of weight, and pain, should not exclude the possibility of a tumor.

Urinalysis.—While gross blood in the urine at the time of examination is of considerable value, the practical value of microscopic blood in the urine is not so great. The possible causes for the existence of a few red blood cells in the urine are so many that their discovery, as a rule, is of little diagnostic value. Hematuria with renal tumor, however, is usually either gross or is absent entirely. Pus may be found in varying amounts in the urine. A small amount of pus will usually occur as the result of secondary infection when there is interference with the drainage of urine. With marked secondary infection the pyuria may become so noticeable that the condition is easily confused with pyelonephrosis. Similar criticism may be made of the value of microscopic pus as with the presence of red blood cells in the urine.

Cystoscopic Data.—By means of the cystoscopic examination we can obtain data which in most cases will enable us definitely to determine the source of the hematuria, to ascertain the origin of pain and to identify an otherwise symptomless tumor. These data will be gained through (1) inspection, (2) the ureteral catheter, (3) estimation of renal function, and (4) pyelography.

Cystoscopic Inspection.—The cystoscopic examination of the bladder may reveal: (1) Dilatation of the veins of the bladder; (2) tumor tissue loose in the bladder or protruding from the ureter; (3) blood-clot in the ureteral meatus; (4) atrophy of the affected meatus; (5) marked comparative decrease in volume and force of secretion; (6) unilateral dark-colored secretions; (7) unilateral hematuria. Dilatation of the veins of the bladder is seen only occasionally with conditions other than renal tumors and occurs usually as a result of mechanical pressure from an adjacent tumor. When found with tumor in the upper abdomen, it is strongly indicative of renal tumor. The dilated veins are not necessarily confined to the area surrounding the ureteric orifice, but may be found over the base and walls, more often on the affected side. While the secretion from the affected kidney may appear entirely normal, it not infrequently will have a comparatively dark brownish color, and its volume and force may be much less than that from the other kidney.

Ureteral Catheter.—The data obtained by means of the ureteral catheter are secured through evidence of obstruction and dilatation. Obstruction to the ureteral catheter may result from: (1) Invasion and partial or complete obliteration of the renal pelvis or upper ureter by tumor tissue; or (2) from pressure on the ureter by surrounding tumor tissue, particularly when the tumor is large and involves

the lower pole. Some evidence of dilatation of the pelvis as a result of tumor changes may be obtained through the discovery of residual urine in the pelvis. Similarity of pain caused by pelvic overdistention is not to be relied on.

Estimation of Renal Function.—Evidence obtained through an estimate of comparative decrease in the functional activity of the two kidneys in the presence of abdominal tumor, may be of considerable diagnostic value. Of the various functional tests, phenolsulphonephthalein is generally considered preferable, because of the simple technic involved and since it permits a comparatively accurate quantitative estimate. In order to estimate the comparative functional

FIG. 115.—Median displacement of pelvis as the result of neoplasm.

activity of the two kidneys, an intravenous injection of 1 c.c. of phthalein solution is made. The amount of dye return in the urine collected separately from the two kidneys during fifteen or thirty minutes is then estimated. Although a considerable portion of the substance of the kidney may be invaded by tumor tissue, the remaining kidney tissue will often secrete almost as great an amount as the entire kidney, and as a result a quantitative functional estimate may not show a decrease sufficient for a definite estimate of the disease. When the remaining renal tissue becomes involved in some secondary inflammatory process as evidenced by pyuria, microscopic or macroscopic, the functional capacity will be markedly reduced. With small tumors, in which the urine is normal, the functional tests

are usually of little diagnostic value. It must also be remembered that pressure of an adjacent tumor may diminish the functional activity of an otherwise normal kidney. Marked hematuria may unfortunately interfere with its use and abate its value (Fig. 115).

Pyelography.—In the majority of kidneys operated on for malignant renal tumor the pelvis is found involved to a varying degree. Abnormality in pelvic outline consequent to such involvement can be demonstrated in the roentgenogram by injecting opaque solutions (silver colloid thorium) into the renal pelvis. In order to distinguish the normal from the abnormal, the outline must vary considerably. The changes in the pelvic outline as seen in the pyelogram will be found as follows:

1. Retraction of one or more calyces well into the cortex giving a bizarre, "spider-leg-like" appearance.
2. Partial obliteration of the pelvic lumen by invading renal tissue, leaving narrow crevices which appear in the pyelogram as thin streaks.
3. Irregular pelvic dilatation following tumor necrosis or secondary infection.
4. Retraction and consequent dilatation of the upper ureter by surrounding tumor.
5. Abnormal position of the renal pelvis so that its outline is displaced in either an extremely median or lateral direction.

Needless to say pyelography should not be employed except where other means of diagnosis fail to identify the tumor. While it causes no permanent injury, it occasionally will be accompanied by considerable pain unless carefully employed. It will be found particularly valuable in identifying renal tumor where the clinical data do not suggest involvement of the urinary tract and where the differential functional test is of uncertain value.

Tumors of the Renal Pelvis.—Tumors originating in the renal pelvis are not common. Epithelioma are most frequently found and usually occur as the result of some chronic irritant such as pelvic stone. Carcinomatous ulceration has been described. Several cases of pelvic leukoplakia have been reported.

Tumors of the Capsule.—Tumors lying adjacent to the kidney but without evident connection are occasionally found. Histologically they are sarcomata and evidently originate in tissuse of the false capsule.

RENAL CYSTS.

Renal cysts may be classified as:

1. Polycystic.
2. Simple.
3. Degenerative.
4. Hydatid.
5. Perinephric.
6. Dermoid.
7. Retention.

Polycystic Kidney.—Subjective Symptoms.—Polycystic disease of the kidney is characterized by the progressive development of multiple cysts in both kidneys, which are of probable embryological etiology. The condition has a tendency to be transmitted to successive genera-

tions. While it has been occasionally found at birth, it usually manifests itself in the adult. The majority of patients suffering from this condition, do not live a normal length of life. As a rule, various complications arise and terminate life at or shortly after middle age. Patients suffering with polycystic kidney present themselves because of renal insufficiency, hematuria or abdominal tumor in the order of frequency.

Renal Insufficiency.—The evidence of renal insufficiency is usually vague and does not manifest itself until the late stages of the disease. The patient may complain of occasional headaches, spells of anorexia or occasional nausea, general lassitude or slight weight loss, and unless a careful abdominal examination and urinalysis are made the underlying condition may easily be overlooked. The evidence of increased blood-pressure, low specific gravity and symptomless tumor, either unilateral or bilateral, should be regarded as suggestive of polycystic kidney.

Hematuria.—Hematuria is present with polycystic kidney in about half of the cases. It may occur as the first evidence of disease but is more often secondary to evidence of renal insufficiency. Although variable in degree, it is usually well marked, persists but a few days and occurs at irregular intervals—somewhat similar to hematuria accompanying neoplasm. Occasionally, however, the hematuria occurs to a less degree and persists over a period of weeks or months, suggestive of essential hematuria. Clot colic as the result of hematuria may be very suggestive of lithiasis.

Infection.—As the cysts increase in size they may be so arranged as to interfere with the drainage from the kidney and cause a complicating renal infection. The evidence of renal infection may then be the predominant feature, recognized by the presence of pyuria, temperature, vesical irritability and pain. The infection may progress to such an extent that a condition of pyonephrosis will develop with evidence of secondary toxic absorption.

Pain.—Pain when present is referred to the area of the kidney and is more often a dull lumbar ache. It may become more severe and is then caused either by the increase in size of individual cysts, rupture of the cysts, mechanical pressure from the tumor itself, or increased intrarenal tension as a result of infection. It may become acute as a result of urinary obstruction caused by the formation of blood clots.

Objective Symptoms.—*Tumor.*—The patient may have no subjective symptoms and consult a physician because of an accidentally discovered abdominal mass. The presence of tumor in both kidney areas would be strongly suggestive of polycystic kidney. It is not necessary, however, that a tumor should be palpable in both sides in order to make a diagnosis. In a large percentage of cases, one kidney only will be definitely enlarged on abdominal palpation. The discovery of unilateral renal tumor might easily mislead one to regard the condition as renal neoplasm. The tumor is often slightly movable,

although when large, it may appear to be firmly fixed. The tumor may appear to be irregular and cystic on palpation, although more often when felt through the abdominal wall, it seems to be quite firm. The polycystic kidney may be of such size as to fill the upper portion of the abdomen and extend to the median line.

Blood-pressure.—In common with other conditions causing renal insufficiency, the blood-pressure is increased to a variable degree. A combination of tumor, either unilateral or bilateral, with a high blood-pressure, should call attention to the possible existence of polycystic kidney.

Urinalysis.—During the latent stage, the urine may be quite normal. As the disease progresses and the secretory tissue becomes involved, and even before clinical evidence of insufficiency is present, the specific gravity of the urine becomes abnormally low. A variable amount of albumin, together with occasional hyalin and granular casts and a few pus and red blood cells may also be present in the urine. The presence, therefore, of a persistent low specific gravity, microscopic evidence of disease in the urine, high blood-pressure, pain in the area of the kidney, and bilateral renal tumor, should be considered of pathognomonic value.

Functional Tests.—Aside from the clinical evidence of renal insufficiency, further data may be obtained by renal functional tests. If phenolsulphonephthalein is used, our attention will often be called to a moderate reduction of renal function when the clinical symptoms are indefinite. It is of particular importance in the occasional case in which the clinical symptoms would not suggest a marked degree of renal insufficiency and when there is a return of but a trace of phthalein. Not infrequently, however, there is well-marked clinical evidence of renal insufficiency without a similar degree of reduction in phthalein. The test is of greatest value in the estimate of the comparative functional activity of the two kidneys. This may not always be ascertained by the comparative size of the kidneys nor by the comparative amount or character of the urine collected from each kidney. The blood urea estimate may also be of prognostic value in estimating the degree of nitrogen, particularly when taken in conjunction with the phthalein test.

Roentgenographic Data.—The roentgen examination may reveal the diffuse outline of a mass in the area of the kidney. Occasionally secondary calcareous deposits are found in the polycystic kidney, which may cause considerable confusion (Fig. 116).

Cystoscopic Examination.—Cystoscopic examination is indicated in the presence of hematuria, unilateral tumor of doubtful origin, and of infection. In the presence of hematuria, its value is obvious in localizing the source. Although the hematuria is usually unilateral at the time of the cystoscopic examination, it does not necessarily come from the side with the palpable tumor. In the presence of a doubtful abdominal tumor, the data to be derived from a cystoscopic examination as well as from pyelography may be of considerable value. In

the presence of an infection, the localization, as well as the degree of infection, may be ascertained by means of the cystoscope and the functional test.

The changes in the outline of the pelvis which may occur are as follows: (1) Shortening or obliteration of one or more of the calyces giving the pelvic outline an oval or irregularly squared contour; (2) broad, irregular retraction of the calyces; (3) change in position an axis of the pelvis; (4) inflammatory changes consequent to secondary infection (Fig. 117).

FIG. 116.—Polycystic kidney calyces abbreviated.

Simple Cysts.—Simple cysts are of comparatively rare occurrence. They usually appear in middle life, more often in women. The cyst which is usually single gradually increases in size and often becomes as large or larger than a grapefruit. It is more often found to involve the lower pole of the kidney. The onset may be symptomless and the patient's attention called to the condition by the appearance of a tumor which is generally discovered accidentally. Physical exami-

nation will show a cystic tumor of variable size in the upper abdomi quadrant. Urinalysis is usually negative unless a secondary infecti develops or the cyst becomes directly connected with the renal pelv which rarely occurs. Roentgen examination may show the shado of an indefinite mass in the upper abdominal quadrant. Calcificati in the wall of a simple cyst, which rarely occurs, may give an irregul shadow suggestive of lithiasis. The cystoscopic examination may h of comparative little value except for the data to be derived fro differential functional tests. Diminution of function, as a result pressure from a large cyst, may call our attention to the renal orig

FIG. 117.—Polycystic kidney with calyces retracted.

of a doubtful abdominal mass. The data to be derived through pyelography are of considerable value. The pressure of the cyst may be great enough to flatten the pelvis and diminish to a great extent the size of its outline. Furthermore, the cyst may develop so as to displace the kidney and cause the outline of the pelvis and calyces to extend at unusual angles. As a rule, the cysts are benign in character and will not influence the prognosis of the patient.

Treatment.—Since the cyst gradually increases in size and causes destruction of renal tissue, it should be removed as early as recognized. Further indications for its removal would be the danger of secondary infection, rupture, and renal hemorrhage.

Degenerative Cysts.—Degenerative cysts not infrequently accompany renal neoplasm or tuberculosis. The cystic appearance of the tumor, as occasionally occurs with renal sarcoma may be suggestive of a polycystic kidney. When occurring with renal tuberculosis, the condition is usually significant of considerable natural resistance.

Hydatid Cysts.—Hydatid cysts occurring in the kidney are rare in this country. When found, they invariably occur in patients coming from the Arctic regions or from Australia. The onset is usually symptomless and the patient seeks advice because of abdominal tumor. Pain is occasionally present as a result of ureteral obstruction caused by discharged daughter cysts. Secondary infection may be the cause of symptoms calling attention to renal involvement. The finding of daughter cysts in the urine would be diagnostic of the condition. The presence of a painless cystic tumor in patients living in the Arctic Zone or from Australia should call our attention to the possibility of echinococcus disease. An eosinophilia when present would be of corroboratory value.

Perinephric Cysts.—Tumors of a cystic nature arising in the perinephric tissues are rare. Serous cysts arising from an embryonic remnant of the Wolffian bodies are the most common form. The cyst is usually latent until middle age, when it suddenly enlarges during a period of a few months. The condition is easily confused with simple cyst of the kidney. It will not cause symptoms unless it is situated so as to cause pressure. No data of value are usually obtained from urinalysis, roentgenography, or from cystoscopic examination. The pyelogram, however, may show abnormality of the pelvic outline resulting from pressure of the cyst on the kidney. Evidence of this may be obtained by means of indentation or other abnormality of the pelvic outline or by the abnormal position which the pelvis assumes.

Dermoid Cysts.—Dermoid cysts are extremely rare. It would be impossible to differentiate them clinically from either simple or perinephric cysts.

Retention Cysts.—Thin-walled cysts, which have no clinical significance, are occasionally found on the surface of the kidney. Such cysts are usually small and contain clear fluid substance.

ESSENTIAL HEMATURIA.

The term essential hematuria refers to a renal condition of obscure etiology which is characterized by hematuria persisting over a period of several weeks, usually in moderate quantities and without any other subjective symptoms or objective data. It occurs more often in the adult between the ages of twenty and forty years. The physical examination is usually negative save for the presence of hematuria, and when this is severe, anemia of varying degree may be present. Urinalysis shows nothing abnormal save the presence of blood. Roentgenographic examination is negative. On cystoscopic examination the hematuria is usually seen coming from one kidney and the pyelogram

shows the outline of a normal pelvis. There is no evidence of disturbance of renal functional activity, the blood-pressure is usually normal and the ophthalmoscopic examination negative. The blood count is normal save for a diminution in hemoglobin and the number of red blood cells is in a degree equal to that of the loss of blood.

Etiology.—Much has been written concerning the etiology of essential hematuria, but it has not yet been definitely established. The nephritic theory is hardly tenable in the face of the clinical data. The long period over which the hematuria may extend without any other evidence of nephritis would exclude this theory. It is claimed that kidneys removed at operation for essential hematuria frequently show evidence of nephritic change. But the same may be said of the majority of kidneys which are removed at autopsy from patients who never had hematuria. Furthermore, in a large number of cases of essential hematuria when the kidney is removed, little or no pathological evidence of nephritis is present. Recently our attention has been called to the possibility of the infection of the renal papillæ as a cause of hematuria. The condition has been found at operation when there had been little or no pus in the urine, nor any other evidence usually found with renal infection. That a low-lying kidney might be the cause of hematuria, is also not to be taken seriously since the latter occurs in a very small proportion of cases with renal dystopia. It is evident, however, that essential hematuria occurs as the result of some pathological change in the renal circulation.

Differential Diagnosis.—Other urinary conditions which may be the cause of hematuria and which may be confused with essential hematuria are as follows: Nephritis, renal tumor, various forms of renal infection and lithiasis.

Renal Tumor.—Essential hematuria may easily be confused with hematuria of renal tumor when the other classical symptoms of renal neoplasm, namely, pain and tumor, are absent. This may happen when the tumor involves the upper pole, and when for various reasons it does not permit of ready palpation. The hematuria accompanying neoplasm is usually of short duration, occurs in large amounts and at irregular intervals in contrast with the protracted course and moderate degree usually accompanying essential hematuria. Occasionally the only evidence suggestive of malignancy may be loss in weight, which should always be carefully considered in the presence of hematuria. The diagnosis is often dependent on the cystoscopic and radiographic data. In the presence of renal tumor a diminution of function in the affected kidney may often be ascertained by cystoscopic examination, either grossly or by means of renal functional tests. Evidence obtained through the pyelogram is of diagnostic value when marked deformity of the pelvic outline typical of tumor is evident.

Renal Tuberculosis.—A profuse hematuria occasionally occurs in the early stages of renal tuberculosis without any other subjective evidence of the disease. Such hematuria rarely persists over any length of time without the appearance of other symptoms of renal

tuberculosis. Evidence of tuberculosis in the genitalia, pus cells as well as blood in the urine, temperature, etc., usually accompany the hematuria. If in the presence of an otherwise symptomless hematuria there is anything unusual in the clinical data, a careful search of the urine for tubercle bacilli, and guinea-pig inoculation is advisable.

Chronic Nephritis.—When hematuria occurs with nephritis, it is usually in the later stages of the disease and the other clinical data which accompany nephritis will readily establish the diagnosis. Essential hematuria could hardly be confused with that occurring in nephritis because of the long period over which the various attacks of hematuria may extend without other evidence of renal disease. Hematuria occurring with nephritis is usually less in degree than that with essential hematuria. Nephritis may occasionally occur, however, with indefinite clinical evidence of renal insufficiency and with a recent hematuria of considerable degree.

Infectious Nephritis.—Hematuria with infectious nephritis occurs only during the period of acute infection and usually disappears when it is over. A microscopic examination of the urine will reveal the presence of pus and a bacteriological examination may show the presence of etiological organisms.

Pyelitis.—Acute pyelitis is occasionally accompanied by temporary hematuria, but the evidence of infection readily identifies the condition. The insidious hematuria which occasionally accompanies chronic pyelitis with villous proliferation of the pelvic mucosa may be confusing. Only an occasional pus cell is present in the urine with pyelitis. Evidence of inflammatory change in the pelvic outline may be graphically demonstrated in the pyelogram.

Hematuria may occasionally occur with hydronephrosis as the result of varicosity or insidious infection in the pelvic mucosa. The presence of intermittent pain which usually accompanies hydronephrosis should call attention to a condition other than essential hematuria.

When neither kidney is palpable with polycystic renal disease, a coincident hematuria may be confusing. There is usually some evidence of renal insufficiency present, however, either from clinical data or functional tests. A painless hematuria occurring with renal lithiasis may be readily differentiated by the roentgenogram. With every case of hematuria, therefore, regardless of other clinical data, a roentgenogram should always be made. Hematuria having its origin in lesions in the bladder, may be readily differentiated by the cystoscope.

Treatment.—The treatment of essential hematuria may be subdivided into surgical and non-surgical. Surgical treatment should only be resorted to when attempts to stop the hematuria have been made by the various non-surgical methods. The non-surgical methods consist of: (1) Cystoscopic manipulation; (2) injection of irritants into the renal pelvis; and (3) subcutaneous injection of serum. The hematuria will frequently stop as the result of irritation to the renal pelvis or ureter following repeated catheterization. This may also be accomplished by pelvic distention or by injection of various irritants,

such as solutions of silver nitrate, adrenalin chlorids, etc. The he turia is frequently observed to cease following pyelography. injection of serum (coagulose) will frequently check the hematuri least temporarily. Occasionally it will be necessary to give repe injections before hematuria ceases permanently. Surgical interfer should not be resorted to before these various methods have been t Surgical interference would only be indicated in the presence of following conditions, namely:

1. When hematuria has advanced to such a degree that the pat becomes incapacitated from loss of blood.

2. With complicating infection or persistent pain.

3. When malignancy is suspected because of insufficient clir data.

PLATE III

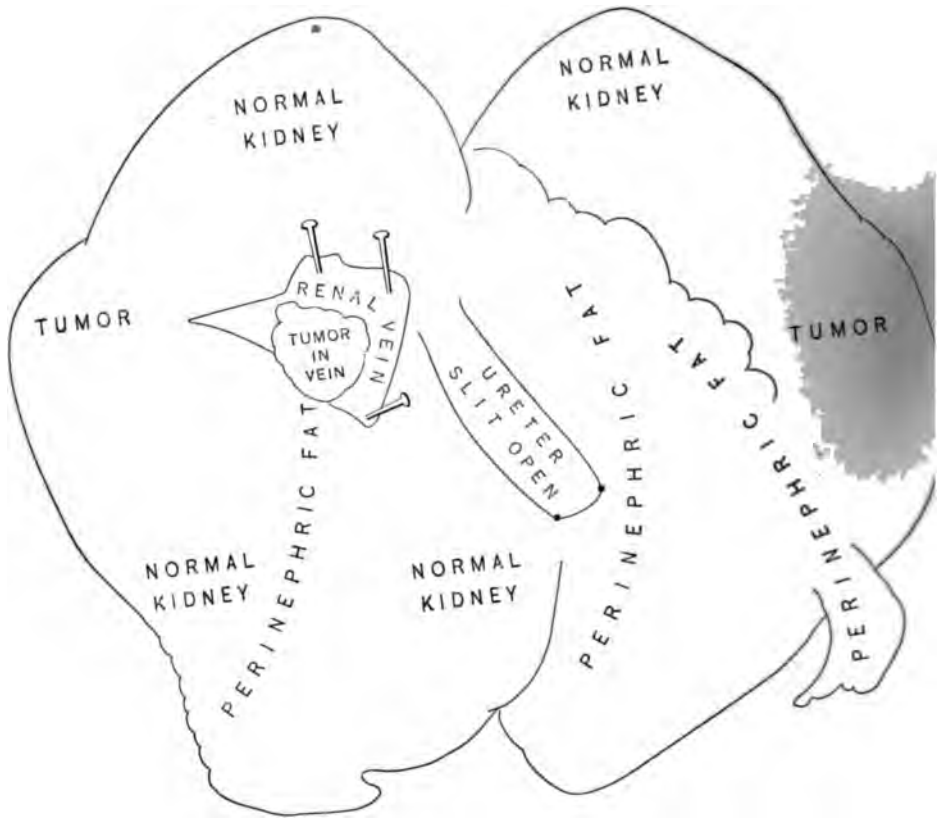

NORMAL KIDNEY
NORMAL KIDNEY
TUMOR
RENAL VEIN
TUMOR IN VEIN
URETER SLIT OPEN
TUMOR
PERINEPHRIC FAT
PERINEPHRIC FAT
PERINEPHRIC FAT
NORMAL KIDNEY
NORMAL KIDNEY

PLATE III

HYPERNEPHROMA.

By HOWARD LILIENTHAL, M.D., F.A.C.S.

HYPERNEPHROMA is a term used to designate tumors showing certain clinical characteristics and conforming to a special histological type.

The mode of development of these tumors has been for some years the subject of controversy among investigators in pathology and embryology. Indeed, to one who glances over the mass of literature on this subject it would appear that hypernephroma may originate in more than one way and perhaps, further study may divide the neoplasm into subvarieties. Even at present we must recognize the benign or quiescent form and the malignant or active one. Fabricius[1] states that he has frequently encountered hypernephroma as an accidental find at autopsy in patients seventy to eighty years old who had no renal symptoms. He maintains that although all cases coming to the surgeon are malignant it is possible to distinguish between the benign and malignant forms at necropsy.

In 1883 Grawitz[2] presented a detailed description of certain renal tumors which had been observed by a number of workers before him. They had accounted for the growths in different ways and had given them various designations. Virchow[3] as early as 1864 had called them struma suprarenalis; Kolaczek,[4] angiosarcoma; Weichselbaum,[5] alveolar adenoma; Swain,[6] Wilson,[7] W. J. Mayo[8] and others mesothelioma. They have also been called perithelioma, spheroidal-celled carcinoma, etc. Grawitz believed that the growths were developed from accessory adrenal bodies. He named the tumors *Struma lipomatodes aberrata renis*. Fourteen years later Birch-Hirschfeld[9] gave it the more convenient name of hypernephroma. Many writers agree with Grawitz as to the origin of the tumors in misplaced adrenal tissue, which has been found in the kidney cortex beneath the capsule, in the liver, in the hilum of the ovary, along the spermatic vessels and in other locations within the abdomen. Also, hypernephromata may exist as primary tumors in the liver,[10] Rolleston[11] even going so far as

[1] Verhandl. d. deutsch. Gesellsch. f. Urol. III Kongress in Wien, 1911, ix, 11-13.
[2] Berl. klin. Wchnschr., 1884. [3] Die Krankhaften Geschwülste, Berlin, 1864.
[4] Deutsch. Ztschr. f. Chir., 1878, vol. ix.
[5] Weichselbaum and Greenisch: Wien. med. Jahrbücher, 1883.
[6] Bristol Med-Chir. Jour., September, 1913.
[7] Jour. Med. Research, 1911. [8] Jour. Am. Med. Assn., March 20, 1915.
[9] Beitr. z. path. Anat. d. Nierengeschwülste; Beitr. f. allg. Path. u. path. Anat., 1898; vol. xxiv.
[10] Adami and McCrae: Pathology, Lea & Febiger, 1912. Kaufmann, Edward: Lehrbuch der Speziellen Pathologischen Anatomie, 1911.
[11] Diseases of the Liver, Gall-bladder and Bile Ducts, 1905, p. 479.

to refer to a primary hypernephroma of the liver "arising in a suprarenal rest." He states that the occurrence of accessory adrenal in the liver was established by Schmorl.[1] The first recorded case of primary hepatic hypernephroma is that of Pepere,[2] in 1902.

In the ovary there have been numerous instances of the occurrence of primary hypernephroma, Gaudier,[3] Vonwiller,[4] Peham,[5] Sternberg[6] and others having reported cases. Vaughan[7] reports a case in which he states "Microscopic examination showed the typical structure of the suprarenal capsule."

Hypernephroma of the adrenal body itself has been rather infrequently reported.[8]

The uterus, according to Ellis, quoted by Vaughan, has been the seat of primary hypernephroma.

In the kidney adrenal rests are commonest, and they may occur in any part of this organ (Kaufmann[9]). Naturally, then, it is to be expected that hypernephroma will be found most frequently in the kidney.

Without going too far into the controversy it may be well to state that though many agree with Grawitz there are at least two other opinions. Stoerk[10] believes that tumors are derived from fully developed kidney structure, and in this he is upheld by Ipsen,[11] who also quotes Sabourin, Sudeck and Zehbe.

Wilson[12] holds energetically to the opinion that both the Grawitz and Stoerk schools are wrong and that hypernephroma arises from nephrogenic tissue ("Primitive renal blastema"). The complete argument would fill more space than is allotted here. It is sufficient to know there is lack of unanimity in this matter. At the same time it is well to remember that, as before stated, primary hypernephroma has occurred in the liver and in the ovary, two locations in which adrenal tissue is not infrequently found.

The appearance of the neoplasm varies considerably as to form, but it is fairly characteristic on gross section. There are globular and botryoidal solid forms, with cysts of various sizes containing yellowish or brownish fluid. Within the solid tumors there may be softening due to hemorrhages. On accidentally violating the tumor during operations there is profuse arterial hemorrhage, for these tumors are extremely vascular. At first there is a well-defined capsule, but with the development of the tumor this is broken down and the malignancy is increased by the invasion of all neighboring parts. In hypernephroma of the kidney there is a tendency to grow into the renal vein and to extend into the vena cava itself.

[1] Beitr. z. path. Anat. u. z. allg. Path, vol. ix, p. 523.
[2] Arch. d. méd. exper. et d'anat. path., 1902, xiv, 763.
[3] Bull. et mém. Soc. de chir. de Paris, 1908, xxxiv, 709.
[4] Ziegler Beitr. z. path. Anat. u. z. allg. Path., 1911, xv, 161.
[5] Monatschr. f. Gebrtsh. u. Gynäk., 1899, x, 685.
[6] Zentralbl. f. Gynäk., 1906, p. 732.
[7] Am. Jour. Obst., 1911.
[8] Bland-Sutton, J.: Keen's Surgery, 1913, vi, 120; Morris, Henry: Surgical Diseases of the Kidney and Ureter, 1904, ii, 15.
[9] Loc. cit.
[10] Beitr. z. path. Anat., 1908.
[11] Ibid., 1912, p. 276.
[12] Jour. Med. Research, 1911.

PLATE IV

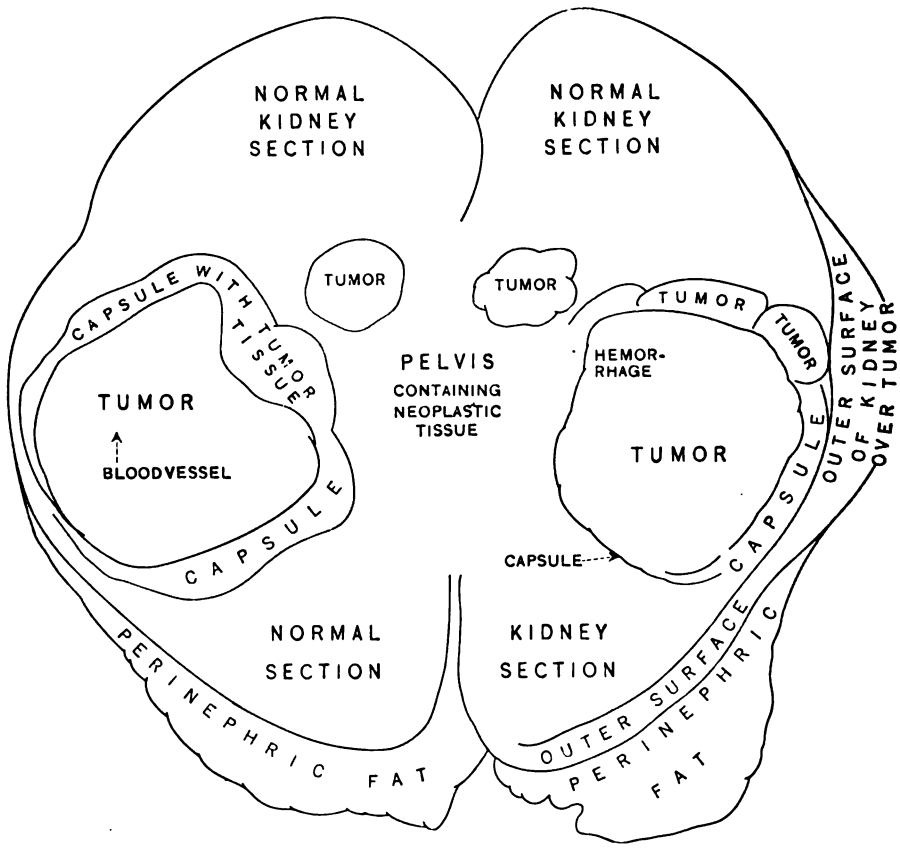

NORMAL KIDNEY SECTION
NORMAL KIDNEY SECTION
TUMOR
TUMOR
TUMOR
TUMOR
CAPSULE WITH TUMOR TISSUE
TUMOR
BLOODVESSEL
CAPSULE
PELVIS CONTAINING NEOPLASTIC TISSUE
HEMORRHAGE
TUMOR
CAPSULE
OUTER SURFACE OF KIDNEY OVER TUMOR
CAPSULE
NORMAL SECTION
KIDNEY SECTION
PERINEPHRIC FAT
OUTER SURFACE
PERINEPHRIC FAT

PLATE IV

Section of the mass reveals a coarsely granular surface of solid nodular or cystic consistency. The solid portions show reddish or brownish and yellow areas, or they are entirely yellow. Indeed, the striking characteristic is the bright yellow color which nearly always occurs over greater or smaller parts of these tumors. Once seen this color is unmistakable.

The specimen represented in Plates III and IV is from a patient operated upon in Mt. Sinai Hospital by Dr. Edwin Beer for renal hypernephroma.[1] Plate III shows the kidney bisected longitudinally and lying on the cut surface. The external portion of the tumor is seen as a spheroidal protrusion on each half of the kidney at about the middle. Note the perirenal fat, the ureter slit open and an extension of the tumor within the renal vein, which has been slit and held in place with pins.

Plate IV shows the cut surface of the specimen. Note the normal portions of the organ unaffected by tumor infiltration; the encapsulated tumor of the bright yellow color. The secondary growth outside the capsule and the renal pelvis containing neoplastic tissue.

The yellow shade has been variously accounted for, some observers attributing it to fat,[2] some to lecithin compounds[3] and others to protagon,[4] a substance of doubtful composition, but apparently a constituent of nerve tissue. The tumors, especially the kidney tumors, may grow very large. Trotter[5] calls attention to the definite encapsulation of the tumors and to their method of growth, as it were, away from the kidney, leaving much of the organ to all appearances normal. Later, as stated above, the capsule is broken through and diffuse extension of the neoplasm occurs. The cyst walls may calcify. Also the kidney pelvis is pressed out of shape, and Braasch[6] has shown that this may be beautifully demonstrated by pyelography. The method proved useful in one of the writer's cases of kidney adenoma, the distorsion being most unusual.

Histology[7].—The structure shows masses of edematous and mucoid connective tissue arranged, for the most part, in an irregular alveolar structure, the framework of which is a widely distributed, thin-walled, vascular network. In the meshes of the latter are collections and strands of large, pale polymorphous and vacuolated cells containing glycogen. This substance, together with the lecithin and chromaffin bodies, is thought by some to speak for the adrenal origin of hypernephroma.[8] A black pigment is also found similar to that normally present in the suprarenal.[9] As a result of focal necrosis there may be perivascular cords of cells radiating around the cell masses. Cysts and grandular tubules have also been seen. The cells contain lipoid elements, which are never normally found in the kidney tubules.

[1] Specimen from which illustration was made loaned by Dr. Bier.
[2] Pfannenstiel: Veit's Handbuch d. Gynäk., 1908.
[3] Kapsammer: Nierendiagnostik und Nierenchirurgie, 1909.
[4] Stoerk: Loc. cit.
[5] Lancet, June 5, 1909.
[6] Ann. Surg., 1910, li, 537.
[7] Fabricius: Loc. cit.
[8] Kapsammer: Loc. cit.
[9] Adami and McCrae: Loc. cit.

Frequently there are numerous hemorrhages as a result of the extremely vascular character of the tumors.

Clinical Course.—Primary hypernephroma of organs other than the kidney shows itself as a tumor more or less malignant, cystic or solid. It cannot be accurately diagnosed before operation unless we except those rare cases of primary hypernephroma of the cortex of the suprarenal body. In this location the growth spreads forward, appearing in the hypochondrium or even in the epigastrium.

FIG. 118.—Metastatic cutaneous hypernephromata. Cicatrix following excision of tumor of cheek. Note tumor of mammary region and of skin below iliac crest.

Guthrie[1] concludes that precocious development may result from tumors of the pituitary or pineal bodies or of the cortex of the adrenal body. There may be hypertrophy of muscle, adiposity and hypertrichosis, the latter being a most striking symptom. The writer once saw, in the practice of Dr. A. G. Gerster, a man, aged about forty years, who had an inoperable abdominal tumor. The patient was emaciated and extraordinarily hairy, with bushy eyebrows. He stated that before the appearance of the tumor he had been what he called a "smooth man" with little hairy growth upon his scalp, no pubic or axillary hair, with hardly any eye-brows. No operation was performed, but the diagnosis of adrenal tumor may be permitted in view of the occasional reports of similar cases of pronounced hirsuties. Chemistry may some day isolate the substance which determines this phenomenon, to the relief of sufferers from premature alopecia.

Metastasis occurs at varying stages, and it is not infrequently the first visible sign of the disease. It takes place through the blood stream and also through the lymph channels,[2] but the tumor may spread by contiguity and also by involving the renal pelvis and the ureter. Secondary tumors may occur in almost any part of the body.

[1] British Med. Jour., 1907, ii, 747; Clin. Soc. London, 1907, xl, 175.
[2] Burkhardt: Deutsch. Ztschr. f. Chir., 1900, p. 55.

Burton Chance[1] has reported a case in which a tumor of the iris and ciliary body was secondary to a hypernephroma of the lower pole of the left kidney, death occurring from intussusception of the ileum, due in turn to a secondary tumor, which was one of many in the intestine and mesentery. Eshner[2] had a patient in whom aneurysm of the aorta was simulated by a hypernephroma of the sternal manubrium. The base of the tongue,[3] of the left ventricle of the heart,[4] the nasal cavities,[5] the lungs[6] and the brain have been the seat of secondary hypernephroma. Martin W. Ware has operated on a case in which there were multiple hypernephromata of the skin with the primary growth in the kidney and other metastases in the ribs and mediastinum (Fig. 118).

But in the experience of the writer, by far the commonest location of metastases is the bones, especially the flat bones. Many observers have called attention to this phenomenon.[7] A woman, aged forty-five years, was operated upon[8] for an enormous renal hypernephromatous tumor. She recovered nicely from the nephrectomy and finally succumbed to a secondary growth in the frontal bone. The metastasis was extremely vascular and exhibited a pulsating thrill like that of an aneurysm. This pulsation is one of the most important points in the recognition of secondary hypernephroma.

The roentgenography of these bone tumors resembles that of sarcoma of the medullary type, remnants of the shaft being usually visible.

Morris remarks that pancreatic disease may be simulated by hypernephroma, and *vice versa*. The following case in the practice of the writer illustrates this:

Sarah M., married, was admitted to the medical service of Mt. Sinai Hospital on August 15, 1910. Four years before, soon after the birth of her first child, there had been recurring right upper abdominal cramps, with pain in the right shoulder, followed by fever and chills, with jaundice and acholic stools. Another attack eight days antepartum came on about three weeks before her admission to the hospital. After confinement she had a chill and temperature of 102°. The child died in a few days. Three days after labor there was right saphenous phlebitis, and a rapidly enlarging mass was found in the right hypochondrium. The liver could be palpated almost to the umbilicus and an indefinite tender swelling, the size of a large orange, was felt in the epigastrium. The patient was anemic and her blood showed 25,000 leukocytes, with 85 per cent. "polys." There was nothing remarkable in the urine.

August 16, with a tentative diagnosis of pancreatitis, an operation was performed by Dr. Elsberg. A normal gall-bladder was found,

[1] Jour. Am. Med. Assn., No. 6, xlviii, 475.
[2] Jour. Am. Med. Assn., May 30, 1908.
[3] Coenen: Zentralbl. f. Chir., 1914, No. 51, p. 1774.
[4] Batsdorff: Breslau Chir. Gesellsch., May, 1913.
[5] Storath: Ztschr. f. Ohrenh., lxix, 157; reported in Zentralbl. f. Chir., 1907, p. 49.
[6] Burkhardt: Loc. cit.
[7] Scudder: Ann. Surg., xliv, 851.
[8] Lilienthal: Med. News, June 18–25, 1904.

the mass extending three and a half inches downward in the median line and one and a half inches to the left. When the covering of omentum was stripped away a cavity filled with chocolate-colored pus and necrotic tissue was evacuated. Drainage with tube was secured. The pathological department reported on the tissue: "Difficult of recognition, but apparently from a glandular organ (pancreas?)." (Buerger.) Pus sterile on culture. After the operation there was well-marked glycosuria, but the sugar disappeared in a few weeks. The other leg now became the seat of phlebitis and the fever continued. There was constant discharge of brownish pus, and two months after her operation I reopened the wound under anesthesia and removed about 500 c.c. of necrotic tissue, which I believed to be sloughing pancreas, but which proved to be hypernephroma on careful microscopic examination (F. S. Mandlebaum). The discharge now rapidly diminished and the wound granulated normally. There was great general improvement, and in less than three weeks the patient insisted upon going home.

In this extraordinary case not only the clinical history and symptoms, including the glycosuria, but even the gross appearance of the necrotic tissue pointed to the pancreas as the seat of the disease. It was never determined in this case where the tumor had its origin, whether in the kidney or, perhaps, in the adrenal body.

It is easily understood how a pancreatic cyst may simulate hypernephroma.

Hypernephroma of the Kidney.—These growths form by far the greater number of renal neoplasms. Pleschner[1] collected from many reliable sources 504 cases of renal tumor, of which 268, or 67.4 per cent., belonged to the variety under discussion. This means that about two-thirds of all kidney neoplasms are hypernephromata. From our own experience this estimate appears too low.

Sex.—Males are more frequently affected than females and the right side more often than the left.

Age.—In malignant hypernephroma the symptoms usually show themselves first between the ages of forty-five and fifty-five, though it is probable that the disease existed, perhaps in a non-malignant form, years before, possibly even from infancy. Otto Frank[2] differs from other writers, and states, in reporting a case of his own, that only 3 others had been known up to that time (1910). His opinion is that hypernephroma is more malignant in childhood than in adult life.

Neither heredity nor injury have been assigned as etiological factors.

Hypernephroma may exist in combination with other pathological conditions of the kidney. It has occurred in horseshoe kidney,[3] in tuberculous kidney,[4] probably antedating the tuberculous infection, and in combination with calculus.[5]

[1] Ztschr. f. urol. Chir., 1913.
[2] Beitr. klin. Chir., 1910.
[3] Clairmont: Arch. f. klin. Chir., 1906, lxxix, 667.
[4] Albrecht, P.: Arch. f. klin. Chir., 1905, vol. lxxvii.
[5] Nogueira, Alejandro: Am. Jour. Urol. Ven. and Sex. Dis., July, 1915, vol. xi

Symptoms.—Hematuria is the first indication of the disease in more than half the cases, and it is probable that microscopic blood will be found on centrifugalizing the urine passed after exercise in at least 80 per cent.[1] The blood may come from the renal tissue itself, because of passive congestion, or it may come from the tumor, which has ruptured its capsule and invaded the renal pelvis. Hemorrhage may be prolonged and profuse, with the passage of clots, or it may be intermittent and slight. It is liable to follow violent exercise or trauma and to subside with rest in bed. Examination of the urine rarely if ever discloses any pathognomonic sign. Albumin will be present from the blood serum, and when the growth is a fairly large one the functional tests may show inadequacy of the affected kidney, but this is by no means constant. Pleschner[2] says that tumor cells are not recognized in the urine, though Grawitz,[3] in his first case, quoted by Weil,[4] found "not only blood but peculiar papilliferous masses of, which the cells were large and ovoidal, so that the diagnosis of carcinoma of the bladder was made."

Burkhardt[5] says that patients die within three years following the first hematuria, but the writer cannot agree with this, having observed several cases in which intermittent hematuria existed for many years.

Julius L., aged fifty-one years, had repeated severe hemorrhages for six years prior to nephrectomy at Mt. Sinai Hospital in April, 1904. Four years later he died of a spinal metastasis without local recurrence. Burkhardt also points out that hypernephroma differs from other renal growths, because it may for years be latent, and in this he is corroborated by Grosheintz[6] and others.

Pain.—Pain of a dull, boring character in the lumbar region, especially on the right side and otherwise unexplained, should raise the suspicion of hypernephroma. It may be years in duration and it may precede hematuria, which then becomes still more important as a diagnostic phenomenon. Colic is not common. Albrecht reports a case in which there was such severe pain in the testicle that castration was performed.

Fever.—Fever of a constant, an irregular or an intermittent type has been referred to by Israel[7] as important, because it may cause confusion with tuberculosis or malaria. He describes the fever as occurring in various malignant kidney tumors, including hypernephroma. The cause of the pyrexia is unknown. There may be: (1) The final fever of cachexia; (2) an initial fever, the only symptom of an otherwise latent tumor; (3) intercurrent fever.

Some hemorrhages are preceded by fever or the temperature may rise after the bleeding. Nephrectomy has caused the prompt disappearance of the fever.

[1] Grosheintz: Ztschr. f. Urol., 1907, p. 545.
[2] Loc. cit.
[3] Virchows Archiv, 1883, vol. xciii.
[4] Ann. Surg., vol. xlvi, p. 418.
[5] Loc. cit.
[6] Loc. cit.
[7] Freie Vereinigung der Chirurgen Berlins, Session 189, November 14, 1910. Reported in Zentralbl. f. Chir., 1911, No. 1, p. 10.

Tumor.—Albrecht[1] found a palpable tumor present in 26 out of 28 cases reported in ten years from Hochenegg's clinic. He rightly warns against energetic palpation, because of the danger of hemorrhage and dissemination of tumor elements.

Hypernephroma may exist in both kidneys, the original case studied by Grawitz having been an example.

The mass is usually of smooth, general outline, though there may be spheroidal protuberances. It may have a solid fleshy feel or it may be cystic both to palpation and anatomically, since hypernephroma tends to break down and form cysts.[2] This process may go so far that there is indeed a true cystic kidney, with hypernephroma in the cyst walls only. The tumor is often quite movable, differing in this from carcinoma and sarcoma, which are, as a rule, bound down by adhesions. It moves with respiration.[3] It is rarely tender unless there has been a sudden increase in its size, due to hemorrhage within the highly vascular growth.

The size of the mass is not always indicative of the duration of its existence, for the hypernephroma may grow rapidly or slowly. The tumor is in the loin, and, unless it is extremely large, the colon may be demonstrated in front of it.

General Symptoms.—These vary with the malignancy of the tumor. Cachexia usually appears late in the disease, though secondary anemia from hemorrhages may simulate a cachetic condition. There is no change in the blood picture except that of anemia. Pleschner[4] emphasizes the absence of cachexia until late in the disease. The writer, too, has noted this, and it suggests to him an analogy with the tumors of the carotid body in which large growths of long duration are not inconsistent with the absence of cachexia,[5] though malignancy it is invariable.

The skin is said by Pleschner[6] to show general or local bronzing similar to that of Addison's disease, and he calls the phenomenon almost characteristic of hypernephroma. In this he has little corroboration, and the writer has failed to note this appearance in any of his cases.

Edema of the legs may be present when the tumor is large enough to impede peripheral venous circulation.

Varicocele of a peculiar kind, which does not empty when the patient reclines, has been described by Hochenegg.[7] When this sign is present it is probable that the tumor is inoperable because of direct implication of the veins. However the same symptom may arise from compression of the spermatic veins by metastatic nodes or by the mass itself.

Differential Diagnosis.—*Carcinoma and Sarcoma.*—Between hypernephroma and the renal carcinomata and sarcomata the diagnosis is difficult. Hypernephroma is, of course, much more frequent than the other neoplasms. The tumor, even when large, is fairly movable

[1] Loc. cit.
[2] Weil, R.: Ann. Surg., xlvi, 418.
[3] Trotter: Loc. cit.
[4] Loc. cit.
[5] Lilienthal: Case Report and Illustration in paper by Callison and MacKenty, Ann. Surg., 1913, lviii, 754-755.
[6] Loc. cit.
[7] Zeitschr. f. klin. Med., p. 62.

while in carcinoma of large size it is fixed, and this characteristic is commoner also in large sarcoma than in large hypernephroma.

Cachexia is an earlier sign in the other malignant tumors than it is in hypernephroma.

The renal tumors of young children are more apt to be sarcomatous.

Although hypernephroma may show lymph node metastases, this form of extension is much commoner in carcinoma.

Tuberculosis.—Tuberculosis is differentiated by the family history and often by the comparative youth of the patient; by the presence of bacilli in the urine; by the frequency of mixed infection; by the cystoscopic appearances in the bladder, especially about the mouth of the ureter on the affected side, and, by the way, in catheterizing these ureters the danger of starting up a severe hemorrhage must be borne in mind. Then, too, there are disturbances of urination and frequently there is disease of the testis and seminal vesicle. In the absence of fever the diagnostic tuberculin injection may be employed. In well-marked kidney tuberculosis the roentgenograph is fairly characteristic, while in hypernephroma there is mere enlargement. The insufflation of oxygen into the peritoneal cavity before roentgenography (pneumoperitoneum) will add greatly to the value of the *x*-ray in the diagnosis. Fluoroscopy should be practised here invariably although permanent pictures are important as a matter of record. Distorsion of the renal pelvis in any kidney tumor may be demonstrated by pyelography.

Hematuria is common in both diseases, but the intervals and course of the symptom are much longer in hypernephroma than in tuberculosis. Weil[1] reports a case operated upon by Kammerer in which there was a free interval of thirty-five years, and intervals of a year or more are not uncommon.

Secondary tuberculous foci are frequent enough, and when occurring in the soft parts it might be difficult to differentiate them without incision. The bone metastases of hypernephroma, however, are quite easily distinguished from tuberculosis, and some secondary hypernephromata are quickly recognized by their powerful aneurysmoid pulsation. Storath's case of intranasal hypernephroma, referred to above,[2] is described as an easily bleeding and strongly pulsating tumor. For emphasis we repeat that renal tuberculosis may occur with hypernephroma.

Pyelitis.—Pyelitis with hematuria is usually accompanied by high fever. Also the caudate cells from the pelvis are found in the sediment, together with other renal elements. But the prompt diagnosis is not always easy, Grawitz's first case having been diagnosed as pyelitis.

Pyonephrosis.—Pyonephrosis should be excluded by the blood count (leukocytosis), by the quantity of pus in the urine and by the cystoscopic and ureteral observations.

Actinomycosis.—Actinomycosis is so unusual as a primary disease of the kidney[3] that it is hardly worth considering, only 3 cases

[1] Loc. cit. [2] Storath: Loc. cit. [3] Israel: Loc. cit.

having been reported to November, 1910. Unless the ray fungus were recovered from the urine preoperative diagnosis would probably be impossible.

Cystic Kidney.—Cystic kidney may be mistaken for hypernephroma and there is nothing in the absence of hemorrhage or other signs of malignancy by which differential diagnosis can be made with precision.

Hydronephrosis.—Hydronephrosis may be suspected when in the presence of a large fluctuating tumor without fever the ureter catheter cannot be passed or when this instrument withdraws much clear fluid, with reduction in the size or tension of the tumor.

Unilateral Hemorrhagic Nephritis.—Unilateral hemorrhagic nephritis and the so-called idiopathic hematuria may be mistaken for neoplasm of the kidney, and in the absence of tumor, cachexia or metastases it may be impossible to differentiate. The writer has operated once for each of these conditions, the case of hemorrhagic nephritis being in a woman in her thirties who died as a result of hemorrhages from the kidney, in spite of nephrotomy, with packing of the wound and plugging of the right ureter with a bougie. No more bleeding after the operation, but death nevertheless from acute anemia. Complete postmortem examination of the entire urinary tract failed to show a probable source of hemorrhage, but "nephritis" was reported.

The other case of "idiopathic hematuria" was in E. B., a medical student, aged twenty-two years, who had suffered for five years with intermittent profuse hematuria, and who came under my observation in October, 1910. After repeated observations nephrectomy was performed, with immediate cessation of the hemorrhages. A most complete examination of the specimen was made by Dr. Mandlebaum, pathologist to Mt. Sinai Hospital, and no possible cause for the bleeding could be discovered. The case was followed for two years, and there was no return of the hemorrhages.

In any suspected case there should be a complete general examination and the patient should be questioned as to "rheumatic" pain in any part of the body. Roentgenography of the chest should be performed and the plate examined for metastases of the thoracic bones or the lungs.

Also, whenever an apparently primary enlargement or tumor of a bone presents itself and the patient is more than forty years old metastatic hypernephroma is one of the possibilities to be eliminated before another diagnosis is made.

A diagnosis of hypernephroma may be made by the excision of a specimen from a metastasis.

Treatment.—Operation is the only treatment in hypernephroma. Nearly all authorities (Albrecht, Trotter, Pleschner and others) urge complete nephrectomy provided the other kidney is present and functionating. If there is more than one metastasis it is questionable whether any operation can lengthen life unless, indeed, nephrectomy is performed to terminate dangerous hemorrhages; but the extirpation of a solitary metastasis plus nephrectomy has been followed by

years of good health.[1] Grosheintz has mentioned the existence of single metastasis as a peculiarity of this disease.

After nephrectomy in cases without secondary growths, freedom from recurrence has been reported as long as ten years. The writer's first case of hypernephroma treated by nephrectomy[2] was in a woman, J. R., aged twenty-eight years, who for four weeks had severe repeated hemorrhages, with right renal colic. At operation (November 30, 1901, at Mt. Sinai Hospital), a lower pole hypernephroma was found. The perirenal fat was friable and adherent to the kidney. Nine years after the nephrectomy the patient was well. Possibly this fortunate result may be ascribed to the early operation, no tumor or enlargement having been demonstrable through the unopened abdomen.

As in other malignant visceral neoplasms the discovery of a palpable tumor augurs ill, and patients who are operated upon before a tumor can be felt have the best chance for cure.

Operative Method.—Since the greatest danger of metastasis is through extension into the renal vein it is desirable to secure this vessel, whenever possible, in advance of the rough manipulations necessary for extraction of the tumor. The transperitoneal ligation of the vessels was therefore advised by Berg,[3] and the principle has been followed by Trotter, W. J. Mayo,[4] and many others. The incision may be parallel with the last rib or it may be continued from its inner end at the edge of the rectus downward or upward, or in both directions. The technic[5] is that known as Langenbach's and is described by Jacobson[6] and Kocher.[7] It gives excellent exposure of the retroperitoneal structures. Having opened the peritoneal cavity and explored for metastases, if none are found the outer, non-vascular leaf of the mesocolon is incised and the colon rolled toward the opposite side, exposing the great vessels. The renal vein is examined and if it contains no tumor masses it is ligated and cut, the artery is treated in the same way and the main blood supply of the kidney being cut off the tumor-bearing organ is easily and often bloodlessly removed. It is necessary, however, to recollect that accessory vessels occasionally enter the upper pole of the kidney and that an artery which may almost be called a secondary renal occasionally arises from the aorta below the true renal artery. This is the vessel which sometimes crosses the ureter, partly obstructing it and causing hydronephrosis.

The ureter should be ligated and divided far from the kidney. A strong but thin strand of chromicized catgut may be used as a ligature and the mucosa of the stump carbolized.

If solid masses are felt in the renal vein the ligature must be beyond them. If the vena cava contains tumor tissue it may be lightly

[1] Trotter: Loc. cit.
[2] Lilienthal: Am. Jour. Dermat., 1904, vol. viii.
[3] Mt. Sinai Hosp. Rep., 1905–6, v, 181.
[4] Jour. Am. Med. Assn., January 31, 1914.
[5] Berg: Surg., Gynec. and Obst., 1913.
[6] Jacobson and Steward: The Operations of Surgery, 4th ed., 1902, p. 152.
[7] Kocher, Theodor: Text-book of Operative Surgery, 3d English ed., p. 674.

clamped, incised, the tumor mass extracted, the incision sutured and the clamp released.

Berg[1] says that in 6 operations of this character there has been but 1 operative death.

In removing the kidney it is best to take away the perinephric fat, but here there are dangers. W. J. Mayo[2] speaks of accidental injuries to other viscera during nephrectomy. The duodenum, the gall-bladder and the colon have been injured in these operations and the greatest care must be exercised to avoid such serious and humiliating occurrences.

The pleura may be accidentally opened even when the twelfth rib is drawn upward and is not resected. This accident is announced by the hissing sound of the entering and escaping air, and the injury must be repaired at once by suture.

Before closing the nephrectomy wound any pads or other elevating devices for holding the patient in position during the operation should be slowly withdrawn (kidney bridge lowered) while the wound is inspected. With the release of the scoliosis, wounded vessels which were on the stretch and not bleeding may suddenly spurt.

The field dry and the peritoneum closed everywhere we are ready for suture. This should be done in layers—at least three; two of fine (No. 2) chromicized catgut for the muscles and fine silk or silkworm-gut for the skin. The chromicized gut sutures should be interrupted and each one tied with three knots.

The writer has had excellent results with the Mayo method of filling the cavity left by the nephrectomy with normal saline solution poured in through a funnel just before the last deep suture is tied and then closing the wound without drainage.

After-treatment.—Although the opposite kidney has been tested before operation, congestion and anuria may arise from reflex shock or from the low blood-pressure of hemorrhage.

The urine of each voiding or catheterization collected in separate glass vessels will enable the surgeon to judge of the work done by the remaining kidney. The first two or three specimens may be expected to contain a little blood, but after this has cleared up a return of the bleeding or the presence of anything abnormal is cause for alarm.

If the tumor was a very large one its sudden removal may be followed by abdominal distention, with consequent cardiac strain. One-tenth grain of eserin salicylate given hypodermically before the patient awakes from the anesthesia, and repeated in six to eight hours, has the effect of spastically contracting the intestine. It is a valuable prophylactic.

Except in the case of infected or gigantic tumors the postoperative course is that of any aseptic nephrectomy. (See article on Kidney Surgery.)

There is a most extraordinary case reported by Bevan,[3] in which

[1] Loc. cit. [2] Jour. Am. Med. Assn., March 20, 1915.
[3] Ann. Surg., vol. xxxix, p. 468.

the patient, two weeks after a normal convalescence following nephrectomy for hypernephroma, developed a diarrhea and passed pieces of hypernephromatous tissue with the feces.

The percentage of operative deaths is about one in four; with 37.5 per cent. following transperitoneal nephrectomy, 33.3 per cent. following lumbar operations, with opening of the peritoneum, and 13.5 per cent. after retroperitoneal nephrectomy. (Pleschner.)

Death following nephrectomy for hypernephroma may result from shock, from peritonitis or, most commonly, from cardiac insufficiency. Israel believes the heart muscle is affected by some toxic substance, but this has not yet been proved.

Postoperative Prognosis.—In view of the fact that very late recurrences have been noted it is hardly possible to regard any patient as permanently cured. However, since numerous cases of long freedom from recurrence have been reported, and since (Albrecht) even after the extirpation of late metastases the patients have remained well for years, it appears that these tumors should be treated in a different fashion from that advised in other malignant growths. As before mentioned a single metastasis present at the nephrectomy is to be removed if operable. A late solitary metastasis should be extirpated and even when there are more than one it may be well to remove them, provided the procedure is not too hazardous.

Fischer reports a metastasis six and a half years after the extirpation of the tumor and Krönlein[1] two cases six and eleven years after operation. Note also the writer's case of Julius L., reported above.

Resumé of Hypernephroma.—1. May be primary in kidney, liver ovary, adrenal, uterus.

2. Commonest in kidney.

3. Symptoms: Pain, tumor, late cachexia, late metastasis. Hematuria when neoplasm involves urinary tract.

4. Metastases, in any part of the body, but commonest in lungs liver and bones.

5. Metastatic tumors frequently pulsate.

6. Treatment: Extirpation. When in kidney, nephrectomy. Extirpation of easily reached metastases, provided all the growths can be removed.

F. N. G. Starr, of Toronto, reported before the American Surgical Association, in June, 1917, a remarkable case in which he removed a tumor weighing eight and a half pounds from the falciform ligament of the liver. The tumor was pronounced hypernephroma by MacKenzie, and appeared to be primary. The patient recovered. The illustration (Fig. 119) shows the tumor *in situ*. Publication occured in the *Annals of Surgery* and in the *Transactions of the American Surgical Association* for 1917.

The writer gratefully acknowledges the assistance of Dr. A. Hyman, adjunct surgeon to Mt. Sinai Hospital, who searched the literature

[1] Münch. med. Wochnschr., 1908, No. 40.

and supplied many references. Thanks are also due to Dr. F. S. Mandlebaum, pathologist to the hospital, for valuable personal communications.

In addition to the literary references in this article there are papers by the following:

Keen, Pfahler and Ellis: *American Medicine*, December 17, 1904 (with 67 references).

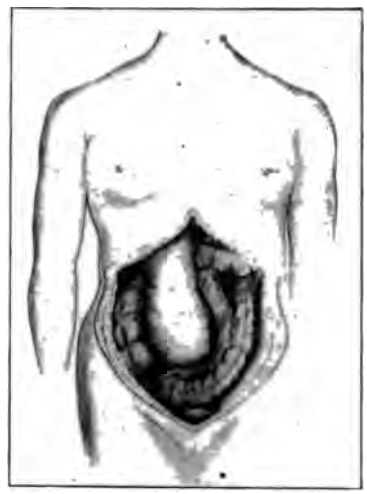


FIG. 119.—Hypernephroma of falciform ligament. (Dr. Starr's case.)

Thorndike and Cunningham: *Boston Medical and Surgical Journal*, December, 1903, No. 23.

Pleschner's article[1] has a list of 100 references.

Kapsammer's work on *Diagnosis and Surgery of Kidney Disorders* has a total of 1827 papers, many of which refer to hypernephroma.[2]

[1] Ztschr. f. urol. Chir., 1913.

[2] Kapsammer: Nierendiagnostik und Nierenchirurgie, 1909.

SURGICAL DISEASES OF THE BLADDER.

By WILLIAM F. BRAASCH, M.D.

CALCULI OF THE BLADDER.

The normal urine is a solution of various organic and inorganic materials dissolved in water, which constitutes about 90 per cent. of the whole. The important organic constituents are urea and uric acid. The inorganic constituents consist of the bases, chiefly sodium, potassium and magnesium, with which the uric acid unites. Other acids, especially phosphoric and sulphuric, form salts with the same bases. These with the chlorides make up the bulk of the inorganic substances contained in the urine. There is, of course, also mucus from the kidneys and bladder and a certain amount of renal and vesical epithelium. When urine is entirely normal and has been passed recently it shows no sediment except a little of this mucus containing a few epithelial cells. After fermentation various amorphous urates form and settle and the urine becomes turbid. Although there are a number of conditions which favor the formation of vesical calculi two main factors are always necessary, a nucleus and a suitable concentration and composition of the solid constituents of the urine.

1. **The Nuclei.**—By careful section of the stone the character of the nucleus can be determined in many specimens. Some of the more common nuclei consist of a few crystals or desquamated epithelium glued together by thick stringy vesical mucus; of blood clots, regardless of their origin, and of localized abrasions of the vesical mucosa such as tumors, ulceration and exfoliative cystitis.

The most common foreign body about which a vesical calculus forms is a renal calculus. A large percentage of all renal calculi pass spontaneously through the entire urinary tract. Only a few are retained in the bladder and form the nuclei of stones because they are too large to pass through the urethra or because of some condition of the bladder or urethra which causes them to be retained, such as obstruction of the neck of the bladder, stricture of the urethra, diverticulum of the bladder, atony of the bladder, etc. Renal calculi which are passed into an uninfected bladder may be retained there for a number of years with but slight growth and no symptoms, and often negative microscopic urinalysis. If the patient is questioned carefully a history of renal colic may often be elicited.

Stones from the lower urinary tract, that is prostatic stones and stones forming in a dilated or sacculated urethra behind a stricture, may pass spontaneously or be pushed into the bladder when sounds or other instruments are passed and continue to grow.

Foreign bodies in the bladder, such as pieces of catheters, bougies, hairpins, pieces of flint rock, rubber drainage tubes, rubber tissue, gauze, sutures, gunshot, spicules of bone and foreign bodies which have migrated into the bladder from other portion of the body, etc., have all been reported (Figs. 120, 121 and 122).

FIG. 120.—Large stones in the bladder formed around the blade of a knife. Blade entered the bladder through the side wall. (Judd.)

2. **Concentration and Composition of the Solid Constituents of the Urine.**—Uric acid, although normally present in the urine in a proportion of only about 1:1000, plays an important part in the formation of calculi, and with the urates, especially those of sodium and ammonium, makes up the bulk of most urinary deposits. Oxalic acid is sometimes found in the urine in combination with lime in the shape of octahedral or of dumb-bell crystals. Phosphatic deposits are composed of admixtures of the alkaline phosphates, sodium and potassium, with the earthy phosphates, the bases of which are calcium and magnesium. When urine in which the urea has been decomposed is fermented into ammonium carbonate, the phosphoric acid unites with the ammonium and decomposition of the triple phosphates takes place, the sediment contains the ammoniacal-magnesium phosphate and calcium phosphate. Cystin rarely is found among urinary sediments in the form of hexagonal crystals smaller than those of uric acid. An excess of urinary deposits in the urine is favored by such general conditions as defective digestion and assimilation, insufficient oxidation, disproportion between the solid and fluid constituents of the

FIG. 121.—Hairpin in the bladder with stony deposit about it. (Judd.)

FIG. 122.—Osteomyelitis of the femur. Piece of bone which has been separated lying inside the pelvic cavity. Cystoscopic examination showed the fragment of bone in the bladder. (Judd.)

diet, excess of meats, fats and sugars, insufficient exercise, etc. An excess of urinary solids is not in itself sufficient to form stones; the presence of the colloids is necessary; they are furnished in the shape of mucus and mucopus in any catarrhal condition of the urinary tract.

Predisposing Causes.—Vesical calculus is a disease of childhood and old age, rarely of middle life.

The shortness of the female urethra and the absence of obstructive diseases render the formation of stones exceedingly rare in the female and when it does occur is usually secondary to the introduction of a foreign body. Barney,[1] in reviewing the cases of stones in the bladder treated at the Massachusetts General Hospital from 1870 to 1919, reports that 442 of the patients were males and 13 females.

Negroes are supposed to be especially free from urinary calculi, whereas the Chinese and Hindus in their own countries have a very high percentage.

Gouty or rheumatic diathesis favors the formation of calculi, especially of the uric acid variety.

Retention of urine in the bladder from hypertrophied prostate, stricture of the urethra, diverticulum of the bladder, atony, lesion of the spinal cord, etc., plays a most important part in the formation of stone and probably is the main cause of the high percentage of vesical calculi in males and in old persons. A catarrhal condition producing an excessive secretion of mucus anywhere in the urinary tract favors the formation of stone.

Characteristics of Vesical Stones.—Stones may be classified according to their chemical composition or according to the circumstances attending their formation. Calculi forming in acid urine are in order of frequency those of uric acid, oxalate of lime, urates, the rarer forms of cystin, xanthin, etc. Calculi forming in alkaline urine, that is, secondary to inflammation of the kidneys or of the bladder, are of the phosphate or carbonate of lime, and of the phosphate of the ammoniaco-magnesium variety. Practically all stones in children are composed of uric acid, and this forms the nucleus of probably two-thirds of all stones.

Density.—The density of a calculus depends largely on its chemical composition. The phosphate stones usually are softer than the other varieties.

Size.—Stones may vary in size from that of a grain of fine sand to one many inches in circumference and weighing several pounds. Osgood[2] has collected from the recent literature 50 cases of unusually large stone, 20 observed at necropsy and 30 at operation. Fifteen of the patients operated on died and 15 recovered, 1 who had a stone weighing 34 ounces. One patient with a stone weighing 46 ounces was operated on and died. In several records of necropsies stones weighing as much as 51 ounces are reported. Generally the longer the stone has existed the larger its size.

[1] Observations on the treatment of vesical calculi. An analysis of 455 cases from the Massachusetts General Hospital. Boston Med. and Surg. Jour., 1919, clxxxi, 462–464.

[2] A large vesical calculus. Report of a case. Tr. Am. Assn. Genito-Urin. Surg., 1913, viii, 135–137.

Form.—The form of vesical stone depends on its chemical composition, whether it is single or multiple, and on the condition of the bladder or the portion of the bladder wall where it forms. Usually stones are oval or rounded, flattened on several surfaces, and, if they are multiple they may present facets. Their surface may be rough or smooth or as irregular as jack-stones, depending on the conditions of their formation. When a foreign body is the nucleus, the accumulated layers of deposit usually conform, in a general way, to the outline of the nucleus. Stones often take the form of the cellule or diverticulum of the bladder in which they form. The idiosyncrasies of the individual bladder are perpetuated in the physical character of the stone.

Growth.—The time required for the growth of a vesical calculus depends on the essential factors of the individual case. Stones which have originated in the kidney and passed to the bladder have been known to remain in the bladder for years with but little growth; on the contrary, there are many instances of thorough incrustation of various nuclei in less than three weeks.

Symptomatology.—In the absence of cystitis a small, smooth, rounded stone may remain in the bladder for many years without giving rise to symptoms. The symptoms of stone are those of cystitis associated with a foreign body, frequency of urination, more marked by day than by night, and urgency. Both frequency and urgency are increased by exercise or by sudden jolting or shifting of the position. If the stone is small and movable it may act as a ball-valve, causing an interruption or even complete stoppage of the urinary flow; the patient can sometimes remedy this by urinating in a different position. The pain characteristic of stone is stabbing and burning, most severe at the termination of urination when the inflamed bladder mucosa comes in contact with the stone. The pain is usually referred along the urethra either to or just behind the external meatus. In cases of retention of urine with stone, the characteristic pain may be absent as the volume of retained urine may be sufficient to keep the walls of the bladder separated. When a large stone is present the pain is often dull, more a sense of pressure than of pain, and is referred to the region of the prostate and rectum. A stone attached to the wall of the bladder or pocketed in a diverticulum may not give rise to any of the usual symptoms. Blood and pus cells in varying amounts, depending on the degree of cystitis, are usually present in the urine. Gross hematuria, usually with the last of the urine, may occur from trauma to the inflamed vesical mucosa. All symptoms vary with the severity of the cystitis and are not in themselves sufficient to allow a diagnosis of stone in the bladder, but serve only to emphasize the necessity of a satisfactory roentgenogram and careful cystoscopic examination.

Diagnosis.—In an occasional case of very large stone in the bladder in the male, the stone can be palpated either through the rectum or suprapubically, or both.

Probably a larger percentage in the female can be diagnosed in this manner. Diagnosis by means of a sound or searcher passed into the

bladder through the urethra to elicit the characteristic click when it touches the stone is not entirely reliable, since, if the stone is attached to the bladder wall, imbedded in a diverticulum, or lying behind an enlarged prostate, the searcher may fail to touch it, and the click may also be obtained by small particles of gritty material in the urethra. Hunner[1] calls attention to the fact that a similar click is obtained on catheterizing with a solid catheter when the urinary flow stops suddenly. Even if the positive sign is elicited it gives usually but little idea of the size and number of the stones or the condition of the bladder. Any one or all of the symptoms of stone, pain, urinary frequency, pyuria, hematuria, etc., are sufficient to call for an *x*-ray examination and to be followed by a cystoscopic examination. The *x*-ray examination should be of the entire urinary tract as a great many renal and prostatic calculi may be shown which have been completely overshadowed by the bladder symptoms. It should also be borne in mind that a larger percentage of stones in the bladder are missed in the roentgenogram than stones elsewhere in the urinary tract.

Cystoscopic Examination.—Cystoscopic examination should furnish information concerning the size and number of the stones, the degree of cystitis, the size and general contour of the bladder, whether or not the stone is free in the bladder cavity, the presence of diverticula, the presence and degree of prostatic hypertrophy or stricture of the urethra, and whether or not retention is present. Particular care should be taken before a negative diagnosis is made, especially if there are suspicious shadows in the roentgenogram or a good history of stone, to rule out the possibility of a stone attached to the dome, buried in a diverticulum, or hidden by a median prostatic enlargement. Not uncommonly a stone is raised out of the base of the bladder on the beak of the cystoscope if the instrument projects too far into the bladder, and in this position the stone usually cannot be seen. Merely withdrawing the instrument a short distance, however, allows the stone to drop back where it can be observed readily. Also the beginning cystoscopist may mistake an organized blood clot on necrotic growths for stone. With a little experience, however, the blood clots are easily distinguished and can be removed through the cystoscope with a specimen taker. Small stones can be removed in the same manner.

Treatment.—The removal of stones in the bladder of the female is usually comparatively simple, since they can be crushed and aspirated without much difficulty. If litholapaxy is contra-indicated either a suprapubic or vaginal cystotomy can be performed. If the stone is an encrusted foreign body, such as rubber tissue or a rubber drainage tube, it can be removed best with a pair of alligator-jawed forceps through a tubular urethroscope, either by drawing the foreign body through the urethroscope, or allowing it to follow the instrument when the latter is removed. In children the suprapubic route of operation is preferable; the relatively large prevesical space not covered

[1] Diseases of the bladder and urethra. Kelly, H. A., and Noble, C. P.: Gynecology and abdominal surgery. Philadelphia, Saunders, 1907, pp. 468–470.

by peritoneum makes the procedure comparatively safe. In the male, lithotrity is the operation of choice, since the attendant mortality is lower and hospitalization shorter than following the open operation.

Suprapubic Cystostomy.—The indications for suprapubic cystostomy rather than lithotrity are: (1) A very large stone which exceeds the limits of the lithotrite; (2) inability to distend the bladder on account of the size of the stone, chronic cystitis, or reduction of the bladder's capacity by previous operation; (3) hypertrophy of the prostate of such size that the blades of the lithotrite are prevented from reaching the base of the bladder; (4) the location of the stone in a diverticulum or in the bladder wall; and (5) the inexperience of the general surgeon in the use of the lithotrite. The choice of general, spinal or local anesthesia is largely a question of the individual case. Although in a difficult case a general anesthetic is much more satisfactory during the operation and following operation since it leaves much less residual soreness.

Lithotrity.—Lithotrity should not be undertaken when the nucleus of the stone is known to be of such composition that it would be difficult to free it from the jaws of the lithotrite and impossible to detach the lithotrite as from pieces of rubber, etc. If the patient has had a previous operation on the bladder or adjacent to the bladder, particularly herniotomy, and the stone is attached to the vesical wall, the possibility of a suture as the nucleus is suggested, and the operator should consider what the result would be of tearing out the suture before using the lithotrite in preference to a suprapubic operation. In the modern lithotrite with fenestrated blade the possibility is prevented of stone fragments packing between the blades and rendering the removal of the lithotrite difficult. Drainage of the bladder following lithotrity is of great value, especially in the presence of marked cystitis. Recurrence of bladder stones is probably slightly higher following lithotrity than following an open operation, possibly because a portion of the stone has been left, or more probably because the original cause of the stone formation, such as diverticulum, hypertrophied prostate, cystitis, stricture, etc., is still present. Regular lavage of the bladder with boric-acid solution and the occasional use of Goulay's solution, free the bladder from the products of inflammation and tend to decrease the number of recurrences.

When prostatic hypertrophy is complicated by stone in the bladder, unless the stone is small and the infection in the bladder very slight, it is much safer to remove the stone only at the first cystostomy and later drain and remove the prostate.

Perineal Section.—The removal of stone in the bladder by perineal section seems indicated only in cases in which another operation is to be performed on the urethra through the same incision.

DIVERTICULA OF THE BLADDER.

Classification.—Anatomically diverticula of the bladder consist of localized sacculations of the wall of the bladder. They are of three

types: the hour-glass deformity, cellules or false diverticula and true diverticula.

Hour-glass Deformity.—Although the hour-glass deformity is a sacculation of the bladder, it is not a true diverticulum. Usually it is congenital, but occasionally it is the result of trauma and involves the entire bladder. The bladder may be divided laterally or along the median line.

Cellules or False Diverticula.—Cellules are small depressions in the wall of the bladder; usually they are multiple, only 1 or 2 cm. in depth, and drain freely into the bladder. In a cystogram the cellules are visible as shallow rounded depressions in the outline of the bladder. They usually occur in conjunction with urinary obstruction and disappear if the obstruction is removed.

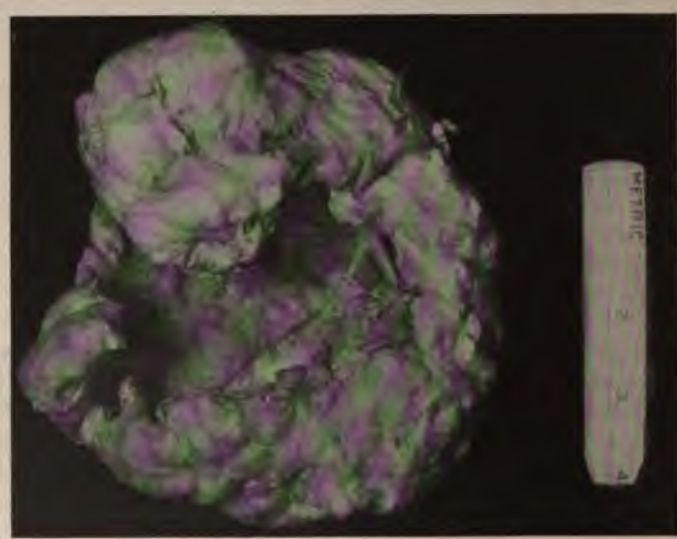


FIG. 123. Diverticulum. (Judd.)

True Diverticula.—True diverticula consist of evaginations of the wall of the bladder and are made up of all the coats of the bladder, muscle, submucosa and mucosa. They vary in size from 2 or 3 cm. in diameter to a sac with a capacity even larger than that of the bladder; the greater number have a capacity of from 1 to 3 ounces. Fully 90 per cent. are situated near the ureteral meatus, anteriorly, posteriorly or laterally, the majority of them being lateral and posterior. Occasionally they are in the lateral wall and in the dome or base of the bladder (Figs. 123 and 124).

Anatomic Data.—Most diverticula as previously stated have three coats. Englisch stated that the difference between true diverticula and false diverticula is that true diverticula are congenital and are made up of all three coats of the bladder, whereas false diverticula are acquired and made up of the mucosa only. However, this

differentiation is not now generally recognized by most pathologists. Rokitansky believes that diverticula are found only in bladders having hypertrophied walls and that the mucosa is forced between the bundles of muscle. Although all diverticula, according to the belief now generally accepted, have the three coats of the bladder, they vary greatly in the thickness of the walls. In most cases the wall of the bladder is markedly thickened, which may be explained by the fact that the muscle hypertrophies in an attempt to empty the bladder. Occasionally the walls of the bladder, as well as those of the sac, are unusually thin, as in young adults without urinary obstruction.

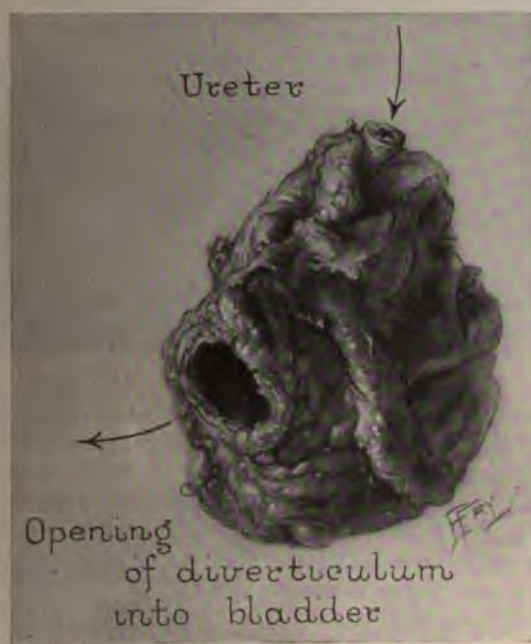


FIG. 124.—Diverticular sac and its opening, which communicates with the bladder. Note the ureter entering the sac. (Judd.)

The relation of the ureter to the diverticulum is important (Figs. 125 and 126). The ureter may be situated in the margin of the diverticulum and careful plastic resection of the mucosa may be necessary. Occasionally the meatus of the ureter is at the base of the diverticulum. If, therefore, only one ureteral meatus can be found, the possibility of the other emptying into the diverticulum must be suspected.

Etiological Factors.—A controversy still exists as to whether the diverticula of the bladder are congenital or acquired. Whether or not a diverticulum could occur without urinary obstruction is a question that has not been answered definitely. The majority of observers believe that the etiological factors are congenital and acquired, that is, the diverticulum occurs in areas of congenital weakness and

FIG. 125.—The situation of the diverticular sac on the left postero-lateral wall and at the base of the bladder. The ureter enters the sac instead of the bladder. The cavity of the sac is approximately half the size of the bladder cavity. (Judd.)

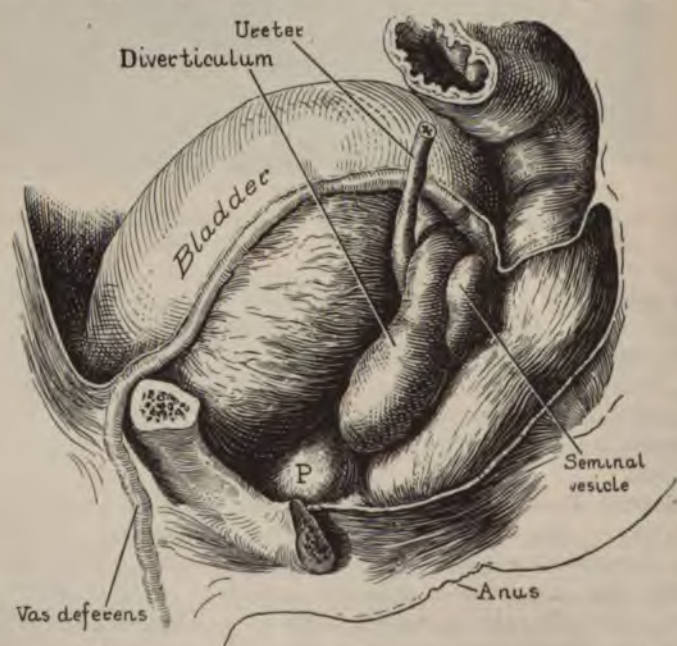


FIG. 126.—Diagrammatic sketch, showing the relation of the diverticulum to the bladder, prostate, rectum, seminal vesicle and ureter. (Judd.)

as a result of urinary obstruction. A number of hypotheses have been advanced with regard to the embryonic factors involved. Cabot is of the opinion that diverticula probably originate from congenital buds of the mesonephric duct which do not go on to ureter formation. Chute believes that diverticula are formed from the pits on the outer side of the ureter.

The evident etiological factor in many of the cases is some form of urinary obstruction. The etiology of the diverticula in young adults and when no possibility of urinary obstruction exists is confusing. Occasionally diverticula also occur in the male adult over forty years of age when no evidence of prostatic obstruction can be demonstrated, and in patients with atony of the bladder without any apparent obstruction.

Pathological Data.—Very often the diverticula are filled with foul purulent urine resulting in extensive peridiverticulitis and adhesions. Such infection usually complicates the condition seriously and the prognosis should be guarded. It may be quite impossible by means of preliminary treatment with lavage, catheterization, or suprapubic drainage, to lessen the infection, and as a result the field of operation may easily become infected. Furthermore, as a result of the peridiverticulitis the consequent adhesions may render excision of the sac very difficult.

Stones are occasionally found in diverticula. Cases have been reported in which a dumb-bell stone was found with one end protruding into the bladder.[9] Secondary malignancy within the diverticulum has also been reported.[11] Although diverticula usually occur singly, there may be two or more, and as many as four large diverticula in one case have been reported. We should not be satisfied by finding one diverticulum but should always look for others. Examination may reveal a diverticulum and at operation another may be discovered. When they are multiple there is usually one on either side of the bladder.

Clinical Data.—Diverticula occur practically always in the male, usually between the ages of forty and sixty, and rarely in the female or in childhood. Occasionally they are observed between the ages of fifteen and thirty if there is no obstruction.

Symptomatology.—*Subjective Symptoms.*—The symptoms are usually those resulting from urinary obstruction. Urinary difficulty may be insidious in its onset and increase gradually. Later secondary infection occurs and the patient has frequency, dysuria and hematuria. Hematuria occurs in about 15 per cent. of the patients and may be very marked. It may be explained by ulceration of the mucosa resulting from secondary infection. In the presence of a pyelonephritis which may result from infection in the diverticulum fever and chills and other symptoms of septic absorption may occur. The symptoms caused by the diverticulum may be completely overshadowed by those resulting from coincident prostatic obstruction.

Objective Symptoms.—Although residual urine is usually present to a greater or lesser extent a diverticulum can be rarely palpated, either by suprapubic or rectal examination.

The possibility of diverticulum must be considered in every case of prostatic obstruction. A large amount of pus in the urine in cases of prostatic hypertrophy should always cause one to make a thorough search for diverticula. The presence of residual urine following prostatectomy when postoperative complications in the prostatic area have been excluded is suggestive of a diverticulum overlooked at the time of operation; a sinus persisting after prostatectomy may also be explained by an overlooked diverticulum.

Renal Function.—An attempt should be made to determine the function of the kidneys in every operation on the bladder. This is done by means of two types of tests: the secretion and the retention tests. The phenolsulphonephthalein test is probably the best secretion test. As in other conditions, the secretion test is of greatest practical value when the percentage return is either normal, or extremely low, as only a trace, or zero. Intermediate values are not so decisive and would still permit of operation. Every test of secretion should be checked up by a test of retention, such as the blood-urea test. If the blood urea estimate is normal and the phenolsulphonephthalein return low, it may be explained by the fact that part of the phenolsulphonephthalein secreted passes into the diverticulum. Consequently, when the patient is asked to void or is catheterized, all the phenolsulphonephthalein is not obtained. In the presence of diverticulum, therefore, secretion tests, such as the phenolsulphonephthalein are frequently less accurate than the retention test, and the two combined give the best results. As an illustration, if a patient has a blood urea reading of about 100 mg. and a phenolsulphonephthalein return of 10 per cent. or less, operation would be contra-indicated. Palliative measures should then be employed and an attempt made to drain and irrigate the bladder. Even though the blood urea is high and the phenolsulphonephthalein return low, this may indicate only a temporary renal insufficiency as the result of long standing residual urine. Following drainage of the bladder the renal function can often be improved to such an extent that the phenolsulphonephthalein and blood urea estimate may return almost to normal limits.

Cystoscopic Examination.—The diagnosis of diverticulum is best established by means of a cystoscopic examination. Although the orifice of the diverticulum is usually visible near the ureteral meatus, it may be difficult to find in the trabeculated or inflamed mucosa and easily overlooked. Particular search should be made in the area around the ureteral openings. It is advisable to distend the bladder in order to stretch the orifice of the diverticulum so that it may become readily visible. It may be difficult to ascertain the size of the diverticulum and to distinguish it from cellules. If the bladder is overdistended, the cellules flatten out so that their bases are plainly visible. In order more accurately to ascertain the size of the diverticulum a leaded catheter is inserted into the opening and a roent-

genogram is made. The outline of the coil in the roentgenogram is the outline of the diverticulum (Fig. 127). A leaded catheter may be inserted into the adjacent meatus and another into the diverticulum and so permit their exact relation to be ascertained in the roentgenogram.

Cystographic Examination.—The cystogram is a very valuable aid in the diagnosis of diverticulum and one which is open to everyone. A cystogram is obtained by raying the bladder injected with an opaque medium (Fig. 128). Probably the best medium is an emulsion of silver iodide, since it is non-irritant and healing to an inflamed bladder. When the cystogram is made in an antero-posterior position only, the outline of the diverticulum may be obscured by that of the bladder and easily overlooked. By directing the rays at right and

FIG. 127.—Stylet coiled in the diverticulum of the right base of the bladder. Opening 3 cm. from the right meatus. Resection of the diverticulum. (Judd.)

left angles the outline of the diverticulum may be distinct from that of the bladder, and it may be clearly demonstrated by emptying the bladder after the two exposures are made and then making another roentgenogram. Hinman suggests a contrast cystogram may outline the diverticulum even more distinctly. This is accomplished by filling the bladder with air after it is emptied of the opaque medium and then making another roentgenogram.

Occasionally the diverticulum is not discovered until at operation. In all prostatectomies or other operations on the bladder, the bladder should be inspected for an opening of a diverticulum.

Treatment.—The treatment of diverticula resolves itself into the best method of excision. It is self-evident that a careful preliminary examination, including tests of the renal function, should first be made in order to determine whether operation is possible. Preliminary treatment, drainage of the bladder and lavage, in the presence of marked infection of the bladder and diverticulum may be of value.

It is very difficult, however, to improve the infection in the diverticulum itself, since drainage of the latter is usually unsuccessful. When there is little or no infection in the bladder and diverticulum, it is usually advisable to proceed with the excision without preliminary treatment, since the latter may bring on marked infection. Efforts should be made, when necessary, to improve the patient's general condition by means of forced fluids, sweat baths, etc.

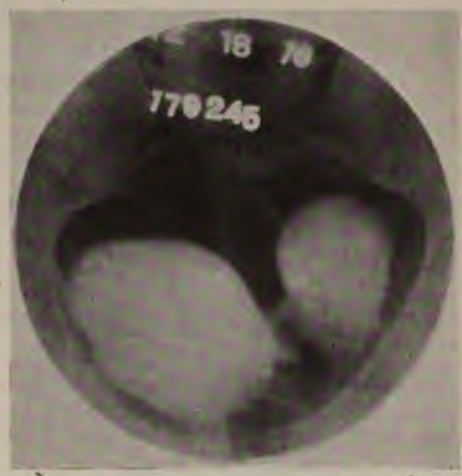


FIG. 128.—Cystogram of a diverticulum from the left base of the bladder, opening 2 cm. posteriorly and to the left of the left meatus. Resection of the diverticulum. (Judd.)

Several methods intended to aid in the resection of the diverticulum have been proposed in recent years. Young places a glass tube in the diverticulum and endeavors by means of suction to evert the diverticulum and then resect it.[12] This makes an ideal operation, but unfortunately the adhesions about the diverticulum are frequently so great that the procedure is not always feasible. Judd puts a finger in the bladder and makes it a basis for resection. Lower inserts gauze into the diverticulum to fill it; Lerche inserts a rubber bag, fills it with water, and in this way outlines the diverticulum. It is very hard to free the diverticulum from the adhesions, and often damage is done to the perivesical tissues. In a series of 44 patients operated on at the Mayo Clinic, all but 10 are reported to be alive.[6] The function of the bladder is normal in all but a few cases. Since coincident prostatic obstruction is so often found it is necessary to make a very careful search for such obstruction in any of its various forms. Contracted vesical neck may also be present, and when found it should be removed. In some cases it may be advisable to perform a preliminary prostatectomy, particularly when the diverticulum is found to be markedly infected.

BIBLIOGRAPHY.

1. Cabot, H.: Some observations upon diverticulum of the bladder. Tr. Am. Assn. Genito-Urinary Surg., 1912, vii, 62–72.
2. Cabot, H.: Observations upon ten cases of diverticulum of the bladder. Tr. Am. Assn. Genito-Urinary Surg., 1914, ix, 53–61.
3. Chute, A. L.: Two cases of diverticulum of the bladder treated by operation. Boston Med. and Surg. Jour., 1912, clxvii, 316–320.
4. Englisch, J.: Isolirte Entzündung der Blasendivertikel und Perforationsperitonitis. Arch. f. klin. Chir., 1904, lxxiii, 1–67.
5. Hinman, F.: Vesical diverticulum. A clinical analysis of twenty-one cases. Surg., Gynec. and Obst., 1919, xxix, 150–172.
6. Judd, E. S.: Diverticula of the bladder. Ann. Surg., 1918, lxviii, 299–306.
7. Lerche, W.: The surgical treatment of diverticula of the urinary bladder, with the report of a case and a new device for facilitating the operation. Journal-Lancet, 1912, xxxii, 337–342.
8. Lower, W. E.: An improved method of removing a diverticulum of the urinary bladder. Cleveland Med. Jour., 1914, xiii, 1–7.
9. Martin, S. P.: Dumb-bell stone in diverticulum of the urinary bladder. Ann. Surg., 1918, lxvii, 94–95.
10. Rokitansky, C.: A manual of pathological anatomy. Philadelphia, Blanchard and Lea, 1855, iii, 48.
11. Young, H. H.: Report of a case of vesical diverticulum containing a cancer. Tr. Am. Assn. Genito-Urinary Surg., 1909, iv, 121–125.
12. Young, H. H.: Excision of vesical diverticula after intravesical invagination by suction; a new method. Surg., Gynec. and Obst., 1918, xxvi, 125–132.

CYSTITIS.

The more exact our knowledge of urology becomes, the more evident does it appear that inflammation of the bladder alone is a comparatively rare disease. Cystitis, as a rule, results from an inflammatory process in adjacent organs or in distant foci, or secondary to mechanical obstruction or trauma.

There is no accepted classification for the various types of cystitis, but for a working basis the following seems comprehensive:

Cystitis due to	Infection	From kidney	Pyelitis.
			Pyonephritis.
			Pyonephrosis.
			Infected hydronephrosis.
			Tuberculosis.
		From urethra	Non-specific urethritis.
			Gonorrheal urethritis.
			Prostatitis.
		From adjacent infections.	
		From distant foci	Teeth.
			Tonsils.
			Syphilis.
	Retention	Prostatic obstruction.	
		Stricture.	
		Cord bladder.	
		Diverticula.	
		Cystocele.	
	Trauma	Stones.	
		Foreign bodies.	
		Instruments.	
		Surgery.	
	Drugs	Poisons	Orally administered.
		Urinary antiseptics	Injected.
	Unknown etiology	Malacoplakia.	
		Leukoplakia.	
		Phosphatic cystitis.	

Infection.—*Pyelitis.*—Immediately following, and probably often concurrent with pyelitis, a secondary cystitis occurs. This is characterized by a diffuse reddening of the mucosa throughout the bladder and a disappearance of the distinct capillary outlines. Clinically the condition is characterized by frequency and dysuria, and if it is severe and the smaller vessels become sufficiently engorged, it may result in hematuria. The condition may go on to chronicity, in which case the diffuse erythema and edema subside and the bladder wall assumes an opaque, velvety appearance, studded with small multiple translucent cysts 2 or 3 mm. in diameter, a condition which is known as cystitis cystica and is always indicative of chronicity. Usually the cystitis subsides with the pyelitis.

Pyonephritis.—The bladder inflammation secondary to this condition resembles in every respect the cystitis found with pyelitis except that because of the greater extent of the renal involvement the bladder condition is generally far more marked. Acute exacerbations of a chronic process are the usual findings, the bladder revealing marked hyperemia and edema, associated with areas of cystitis cystica and other signs of a former chronic condition. On the virulence of the organism producing the pyelonephritis depends the extent and the severity of the bladder inflammation. Cases in which cocci predominate are often most severe, while those in which only the colon organism is recoverable are milder in their course. Cystitis secondary to a pyonephrosis or infected hydronephrosis varies markedly in severity. Often a case of unilateral pyonephrosis in which thick creamy pus is being discharged into the bladder show but little, if any evidence of cystitis, while the mild infection of a hydronephrosis may be characterized by a severe grade of cystitis, producing marked irritability or vesical tenesmus. Again the difference in reaction must be attributed to the infecting organism, for often clinically a patient complains only of abdominal pain and pyuria, there being no symptoms referable to the bladder, with a very advanced infection of the kidney. These cases are not in the majority, but occur sufficiently often to emphasize the point that a mild or absent cystitis is not always indicative of the absence of disease of the kidney.

The treatment of these conditions of the bladder which are secondary infections of the kidney demand the removal of the causative factor in the kidneys by appropriate treatment, together with the local treatment of the resulting condition of the bladder by means of daily bladder lavage with boric-acid solution, followed by the injection of a small amount of some mild antiseptic solution, such as silver iodid emulsion, argyrol, or weak solution of silver nitrate.

Tuberculous Cystitis.—Tuberculous cystitis, occurring without a previous renal involvement, rarely if ever exists. Symptomatically, the condition is characterized by frequency, dysuria and often hematuria. The dysuria and frequency are most marked, often developing into severe tenesmus, the bladder capacity decreasing with the course of the disease until but 1 to 2 ounces of fluid can be retained.

Cystoscopically, the picture is often so characteristic that a diagnosis is possible without further tests. The inflammation, especially in the early stages, is usually confined to the side of the bladder corresponding to the infected kidney. In the early stages there are discrete areas of intense inflammation, in the centers of which are seen pearly-colored spots, or tubercles, which have received the name of "sago bodies." Later these tubercles coalesce and form localized areas of ulceration with intensely red peripheries. As the disease advances, these larger areas coalesce; the bladder becomes a small contracted ulcerative sac, which bleeds with the least trauma, and from the walls of which necrotic tissue hangs in shreds. The ureteral meatus on the affected side becomes retracted and gaping, giving the golf-hole appearance so characteristic of the disease.

Following the removal of the infected kidney, regression of the bladder condition will result which will not reach its full extent until one or two years after operation, and the extent of such recovery will be in direct proportion to the extent of involvement prior to the operation. This regression of inflammation may be hastened by bladder lavage, and in certain instances after the recovery has become stationary, may be further stimulated by the treatment recommended by Rovsing, which consists in irrigating the cocanized bladder with increasing percentages of carbolic acid, starting with 0.25 per cent. and increasing to 6 per cent. Complete recovery of function is seldom secured. Occasionally before the bladder condition has progressed too far, the ureter on the affected side becomes occluded and autonephrectomy results, with a recovery of the former cystitis. Such cases are rare, but account for the spontaneous cures occasionally reported in cases of renal tuberculosis.

Urethritis.—Inflammation of the urethra, either the result of a Neisserian infection or of non-specific origin, may extend to the bladder, in which case the greatest inflammation exists in closest proximity to the urethra, namely of the trigone.

True gonorrheal inflammation of the bladder is rare, although generalized cystitis, secondary to infection of the prostate or vesicles, often occurs. This will be discussed under the heading of cystitis due to inflammation in adjacent tissues.

Especially in elderly women, due probably to lowered resistance and relaxation, a low grade urethritis often extends into the bladder and involves the trigone, the trigonitis being the chief manifestation of the disease. The trigone becomes injected, reddened and excessively tender. Treatment should be directed equally against the inflammation in the urethra and that in the trigone. Topical applications of silver nitrate, 10 per cent., through an endoscope are often of great benefit.

Prostatitis.—Prostatitis is often, if not always, associated with cystitis in the male. The edema and hyperemia, co-existent with the prostatic infection, causes a marked inflammatory condition of the bladder, often general, but often confined to the base of the trigone.

Adjacent Infection.—Inflammatory disease of the pelvis may result in cystitis by continuity, or by a diseased appendix which may be pelvic in position, and, similarly, by diverticula of the sigmoid and inflammation of the seminal vesicles; all tend to produce secondary cystitis, often of severe type. Such inflammations either produce a diffuse cystitis with increased inflammation in the areas immediately adjoining the bladder, or the cystitis may be confined to the position of the infected adjacent organ. This is particularly true in cases of seminal vesicle inflammation; the localized cystitis becomes marked, is characterized by edema, the mucosa is raised in red and edematous folds, "bullous edema," and, if the process has been of long duration, necrosis and sloughing of such areas may result, making the cystoscopic picture difficult to distinguish from that of malignancy. Edema occurs in cases of severe cystitis secondary to kidney lesions, but most often it is found associated with inflammatory processes adjacent to the bladder, which have involved its walls and when seen always excite suspicion of extravesical origin and adjacent infection.

Teeth and Tonsils.—Recently it has become apparent that different urinary infections have their etiology in distant foci such as the teeth and tonsils.[1] This is true of the so-called submucous ulcer first described by Hunner. The syndrome of this condition is characterized by marked frequency and dysuria, patients are often compelled to void several times an hour both day and night, and frequently give a history of acute localized pain, often exaggerated by walking or riding and located deep in the pelvis, generally to one side. Urinalysis in these cases is frequently negative and never shows more than a few leukocytes and a few erythrocyte cells. On cystoscopic examination the greater part of the bladder is normal, and generally on the dome or on one of the walls is an area of increased hyperemia, the center of which is blanched. There is no slough or appreciable break in the mucous membrane. When this point is touched either by the cystoscope or by a ureteral catheter extreme pain is elicited. The treatment of these conditions consist in the resection of the involved bladder wall, all possible foci of infection having been first removed, since if the latter procedure is neglected a recurrence of the ulcer in another portion of the bladder is probable. On pathological examination the removed tissue shows round-cell infiltration extending through all coats of the bladder and often involving the peritoneum.

Syphilis.—Syphilis of the bladder is a comparatively rare condition. During the secondary stage the mucosa is probably involved in a manner similar to the other mucous membranes of the body, but as the involvement does not produce symptoms, it is rarely seen cystoscopically and is of little diagnostic aid as the diagnosis of the disease can usually be made from lesions elsewhere and their confusion with other conditions of the bladder is not liable to occur in the presence of a general eruption over the rest of the body.

[1] Bumpus, H. C., and Meisser, J. G.: Focal infection and selective localization of streptococci in pyelonephritis. Study I. In Press.

Tertiary lesions are usual and are chiefly of interest because of their marked resemblance to neoplasms. The gumma, however, when found in the bladder wall generally gives the appearance of degenerative changes, with sloughing and necrosis, while with neoplasm regenerative areas are in evidence. However, it is often necessary to remove portions of the tumor substance for microscopical examination in order to make a definite diagnosis. Condylomas occurring in the bladder have also been described and resemble closely benign epitheliomas. The differential diagnosis here is also rather difficult; the condylomas, however, disappear under treatment for syphilis.

Retention.—In whatever part of the urinary tract retention occurs, it is sure sooner or later to be accompanied by infection. The most characteristic example is the retention found in the bladder as the result of prostatic obstruction. This may often reach large proportions, the bladder changing from a pelvic to an abdominal organ and containing as much as 60 or 70 ounces of urine. In such cases the cystitis is diffuse and often very acute. The bladder wall between the muscle bands is sacculated; the muscle bands stand up as distinct ridges, which are called trabeculations. Such trabeculations may be more acutely inflamed than the bladder wall which lies in pouches between them. They occur also in cases of long-standing urethral stricture and in paralysis of the bladder due to disease in the spinal cord. In these so-called paralyzed or cord bladders the trabeculations and sacculations are almost identical with those found in cases of prostatic obstruction and urethral stricture. The cystitis is general and is kept aggravated by the inability of the bladder completely to contract and to expel its contents. The result is a varying amount of residual urine. The treatment of these two conditions is identical, that is, doing away with the residual urine. In the first condition the prostate is removed, or the urethral stricture is dilated; in the second condition the bladder is kept empty by means of a permanent urethral catheter or by frequent catheterization. Cord bladder occurs far less frequently in females than in males. Diverticula of the bladder, when they do not empty often contain foul and purulent urine, which by its presence keeps the entire bladder inflamed and produces chronic cystitis. A similar condition occurs with cystocele in women; the bladder's inability completely to empty results in residual urine, infection and inflammation.

Trauma.—Any trauma of the bladder will result in localized inflammation, and, if extensive enough, in generalized cystitis. Stones from the kidney or ureter, which have lodged in the bladder, by their constant movement and continual growth result in severe irritation of the bladder mucosa with a very marked cystitis. Stones which have formed as the result of prostatic obstruction and residual urine are probably the result of the infection and cystitis produced by the obstruction, and not the cause of the cystitis, which, however, they aggravate and keep acute.

Foreign Bodies.—Foreign bodies of almost every description have been recovered from the bladder, especially in the female. Parts of surgical instruments, such as the ends of catheters and bougies, which have become encrusted with urinary salts, act in every way in the production of cystitis as do stones. One of the most frequent sources of cystitis is undoubtedly the introduction of infection and trauma produced by instrumentation. However, the trauma, not the infecting organisms introduced, is probably the chief cause of the cystitis, for it is doubtful if catheterizations carefully carried out with sufficient lubrication will cause infection, and probably many of the cases of postoperative cystitis which were formerly attributable to the necessity of catheterization incident to postoperative care are really due to the passage of instruments through the urethra without proper lubrication. Much experimental evidence is now available to show that the mere injection of infective organisms into the urinary tract without the production of trauma does not result in infection. Surgery, especially if undertaken in the region of the bladder, often produces cystitis, probably due to trauma incident to the operation and manipulation of the bladder. Cystitis of this nature should be treated with irrigations of boric acid solution and the oral administration of hexamethylene.

Drugs.—Drugs may be the cause of cystitis when taken orally or administered intravesically. Cantharides and turpentine are the most typical drugs producing cystitis from oral administration, while cystitis following the administration of hexamethylene is seen frequently. This drug is undoubtedly a valuable urinary antiseptic; in an acid urine it breaks down into formaline. Its administration, however, should be watched with care and the patient should never be allowed to use the drug for long periods. Ten days to two weeks' administration will result in the maximum of benefit, if careful attention has been paid to the acidifying of the urine. Acid-sodium phosphate given in equal doses is the most valuable agent in producing this result. The intravesical administration of almost any of the common drugs used to irrigate the bladder may, if continued for a long time, produce rather than alleviate severe grades of cystitis. Boric-acid solution, which should be used more generally when long-continued bladder lavage is necessary, is probably the only exception to this rule.

Unknown Etiology.—Malacoplakia is a disease of the bladder mucosa which is not often seen. Its etiology is unknown. Its cystoscopic picture is that of a hypoplasia of the wall of the bladder in localized areas encrusted with urinary salts. It is very liable to be confused with neoplastic growths and resembles very markedly severe grades of ulcerative cystitis; the evidence of hypoplasia, however, is more marked.

Leukoplakia.—Leukoplakia, as the name implies, is a disease of the mucosa of the bladder resembling leukoplakia of the mouth. It is probably the result of infection associated with atrophic changes of the mucosa of the bladder, but may be a precancerous condition. It

is generally localized to one area, slightly raised and very firm and fibrous in consistency; it is rather resistant to fulguration.

Phosphatic Cystitis.—Phosphatic cystitis is met with in patients with alkaline urine and its symptomatology resembles that found with neoplasms and tuberculous cystitis. Hematuria is one of the chief symptoms and is associated with marked frequency and dysuria. On cystoscopic examination the bladder is found intensely red and irritable, and in areas throughout its entire extent incrustations of phosphatic material which cling tenaciously to the inflamed wall when their removal is attempted by instrumentation. The disease responds readily to the administration of sufficient Bulgarian bacilli intravesically to overcome the alkaline reaction. Bulgarian bacillus tablets should be ground up in a mortar to produce a creamy paste; approximately 1 to 2 ounces are injected twice a day; during this time large doses of acid sodium phosphate should be given orally. The phosphatic areas which do not respond to this treatment may be curetted off in the female patient in the knee-chest position, or applications of 10 per cent. silver nitrate may be applied locally. When the condition is cured, the patient should be warned to watch the urine carefully as to its reaction, never permitting it to become alkaline. A *Micrococcus ureæ* is said to be the etiology of this condition.

The treatment of cystitis in general should consist of an attempt to alleviate any retained urine by free drainage, either by intermittent catheterization, in-dwelling urethral catheters, or by suprapubic drainage. No one drug can be recommended as more efficacious than all others, as what will prove beneficial in one case will act as an irritant in others. After several of the standard lavage solutions, such as argyrol, Goulay's solution, silver nitrate and silver iodid, have failed to effect a diminution of the bladder inflammation, the institution of drainage suprapubically by means of a large caliber catheter will often produce most gratifying results. When once the pathological condition has subsided, the drainage may be removed. Such drainage answers every purpose that drainage instituted from below either through the vagina or perineum will produce, and has the added advantage of not resulting in permanent urethral fistulæ.

TUMORS OF THE BLADDER.

Classification.—Tumors of the bladder may be classified according to tissue: epithelial, connective or muscular.

Epithelial-tissue Tumors.—Papilloma and carcinoma, the two main types of epithelial tumors, comprise almost 90 per cent. of all tumors of the bladder.

Papillomas are the most frequently observed tumors of the bladder. They are composed of a branching connective tissue center, with a fine network of vessels, covered by an epithelial layer. They bear a marked resemblance to the vegetable cauliflower. Most of them

have a distinct small pedicle, although occasionally a large number of small papillomas are attached together to the mucous membrane of the bladder. Papillomas are of two distinct types, benign and malignant. While it is true that all papillomas are potentially malignant, a large proportion run a clinically benign course; it is sometimes very difficult to distinguish the two types through clinical methods.

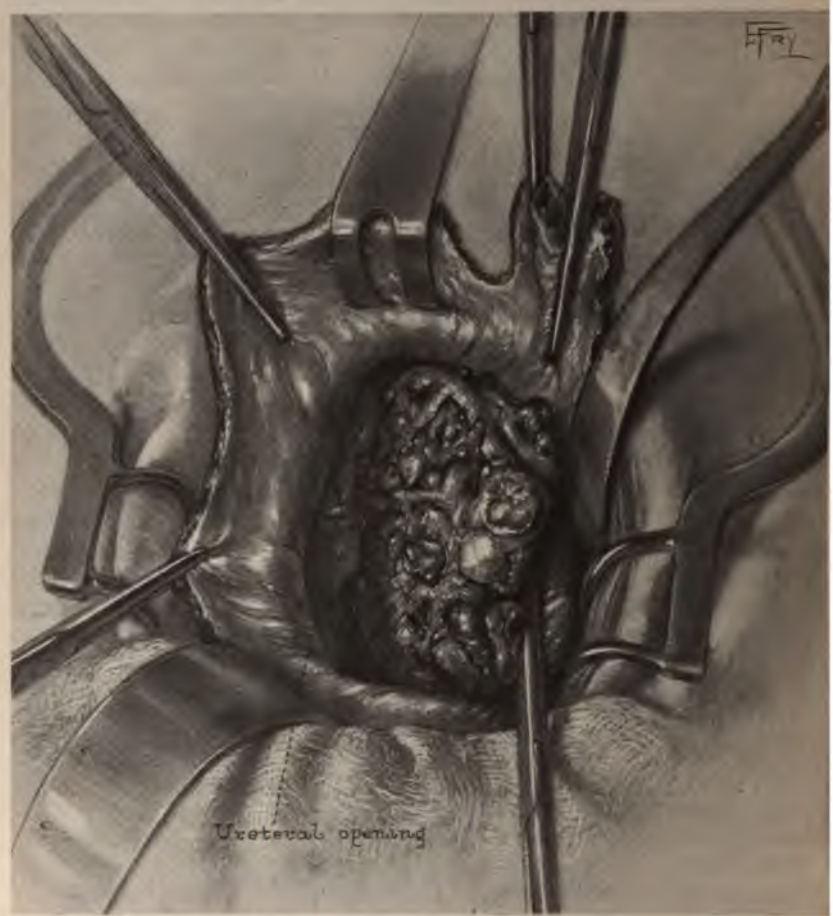


FIG. 129.—Large carcinoma involving the right base and lateral wall of the bladder. (Judd and Harrington.)

On microscopic examination benign papillomas are characterized by regularity in outline and arrangement of cells, and there is no invasion of the basal membrane. Malignant papillomas are characterized by: (1) Greater irregularity in cell arrangement; (2) increased mitosis of the cells; (3) difference in intensity of the nuclear staining qualities, and (4) invasion of the cells beyond the basal membrane. Benign

papillomas may become malignant, but as a rule they remain benign for a long time (Figs. 129, 130 and 131).

Carcinomas are of three types, papillary, flat and solid. The papillary tumors are covered by papillæ of varying length, with a cellular structure, characteristic of malignancy. The flat tumors usually have an ulcerative center, and are surrounded by irregular nodules. The solid tumors project into the bladder lumen as thick, meaty growths, or burrow deep into the submucosa and musculature, or even into the perivesical tissues.

FIG. 130.—Front view of intra- and extravesical papillary angiomyxoma. (Judd and Harrington.)

Connective-tissue Tumors.—Included in the group of connective-tissue tumors are sarcoma, myxoma, fibroma and angioma.

Muscular-tissue Tumors.—The muscular-tissue tumors of the bladder are the myomas and the fibromyomas; the latter are said to represent about 2 per cent. of vesical tumors. Their clinical course is comparatively benign and they are often characterized by profuse bleeding. True primary sarcoma of the bladder occurs very rarely.

Anatomic Data.—The extent of tumors of the bladder varies; most malignant tumors cover an area of 4 or 5 sq. cm. In 200 cases of tumors of the bladder in which operation was performed at the Mayo

Clinic, from one-third to one-half of the bladder was involved in 4
patients (20 per cent.), and the bladder was completely involved in
patients (4 per cent.). The majority of bladder tumors are situate
a short distance from, or surrounding the ureteral meatus. This situ
tion has been explained on the grounds that the tissues in this are

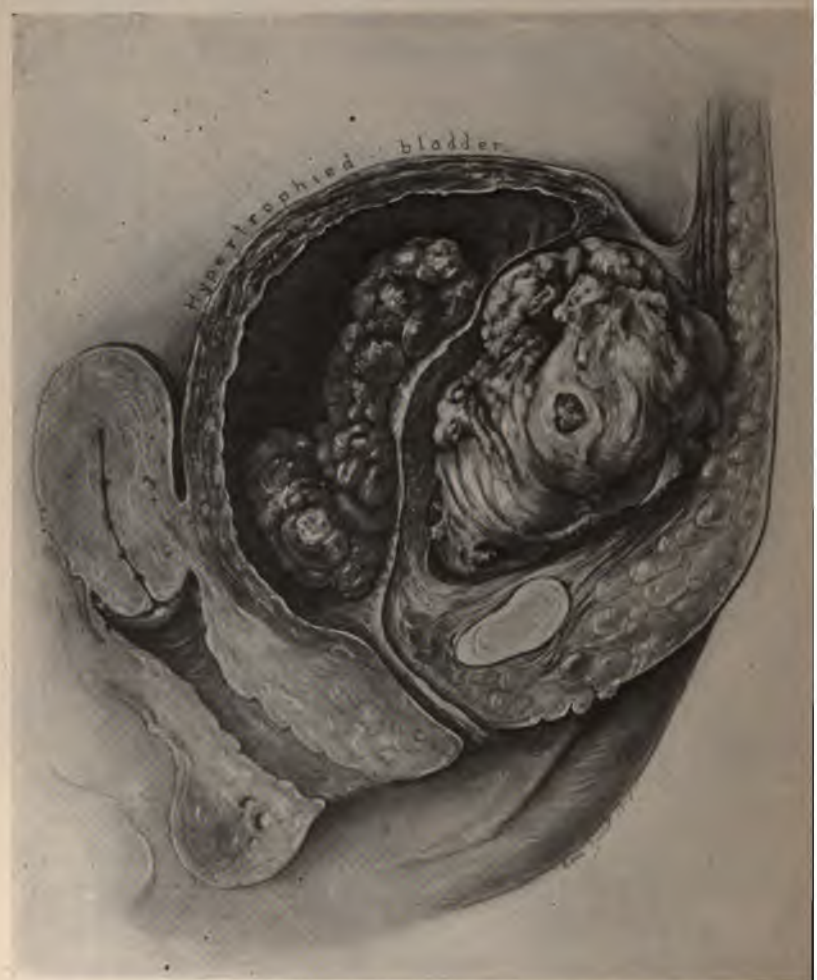


FIG. 131.—Sagittal view of intra- and extravesical papillary angiomyxoma. (Judd a
Harrington.)

have an embryonic defect. Benign papillomas are not so frequent
situated near the ureteral meatus, but may occur in various portio
of the bladder. Only a comparatively small percentage of malign
tumors are found near the dome.

Incidence.—Vesical tumors occur in the male three times as fr
quently as in the female. In the series of 200 cases there were 1

males and 58 females. The condition is found most frequently in patients between forty and seventy years of age. Benign papillomas and the connective-tissue and muscular-tissue tumors usually occur in younger persons.

Symptomatology.—*Hematuria.*—Hematuria is the most important and a usual symptom with vesical tumors. It is unfortunate that the majority of patients operated on have had hematuria for several years, without any attempt having been made to discover the cause. A physician who does not insist that patients with hematuria shall have a careful investigation to ascertain its source is doing them a great injustice. It is remarkable how frequently hematuria is neglected in spite of all that has been said in recent years to emphasize it. No matter what other symptoms may exist hematuria should demand a cystoscopic examination in order to exclude malignancy. Hematuria usually appears at irregular intervals in the early course of the disease, and later becomes continuous; in the earlier stages it is noticeable only at the first part or end of urination.

Urinary Frequency.—Dysuria and frequency usually accompany malignant tumors and follow the appearance of hematuria. Hematuria and frequency are strongly suggestive of malignancy and certainly should be investigated carefully. Occasionally fragments of tumor are passed with the urine. The tumor may be situated so as to interfere with urination and cause definite obstructive symptoms.

Physical Examination.—Rectal or vaginal examination may afford clinical data of great importance. The situation and the type of the tumor and the existence of perivesical extension may all be ascertained. Since the greater portion of vesical tumors, particularly if they are of the penetrating type, are situated at or near the base, frequently they can be palpated on rectal or vaginal examination. If a hard indurated mass is felt extending beyond the bladder wall, it is quite likely that the tumor is malignant and that perivesical tissues are involved. These data, with hematuria and frequency, in a man of forty years or over, is definite evidence of the infiltrating type of carcinoma of the bladder. The penetrating type of carcinoma frequently extends into the walls of the vagina; occasionally it is so large that it can be felt in the bladder on suprapubic palpation. Operation is not of much value in such cases and the prognosis is very grave.

In spite of the fact that metastasis is not common, roentgenographic examination of the chest and pelvic bones is indicated, particularly in advanced cases.

Renal Functional Tests.—Renal functional tests, both of secretion and retention, should be made in every case. An accurate estimate of the phenolsulphonephthalein secretion may be difficult because of residual urine in the bladder or in the ureter. If the phthalein estimate is less than normal it should always be checked up by the retention tests, preferably the estimate of the blood urea. With repeated low phenolsulphonephthalein estimates (10 per cent.) and a high blood urea, of 100 mg. or more, operation is inadvisable. These tests should

be made prior to cystoscopic examination; they may contra-indicate such examination.

Cystoscopic Examination.—The nature, position and extent of the tumor may be ascertained by cystoscopic examination. Benign papillomas are usually recognized easily. They are characterized by multiple slender filaments of tissue of varying lengths floating in the medium. They are pale and glistening and arise from a slender pedicle. The malignant papillomas differ in that the filaments are thicker and have a more meaty, solid appearance, and there may be nodules and edema around the base. Occasionally it is very difficult to differentiate the two conditions by cystoscopic examination alone. Fulguration is a good method of determining whether or not a papilloma is malignant. If it is not malignant fulguration will cause it rapidly to disappear; if malignant, it will not respond readily, if at all, to fulguration. On cystoscopic examination carcinoma is usually easily recognized by its gross appearance. The cystoscopic data differentiating the malignant and the relatively benign papillomatous tumors are: (1) A tendency of the superficial portions to necrosis and incrustation which produce a dirty gray appearance; (2) a heavy, meaty appearance and a thick pedicle, in contrast to the frail structure of a benign papilloma; and (3) the frequent presence of an intractable and very irritating cystitis.

Occasionally it is difficult to distinguish between a papillomatous growth and an ulcer, but as a rule there is sufficient evidence to make the diagnosis. Not infrequently considerable granulation tissue is found near a meatus as the result of chronic infections of the kidney, particularly tuberculosis. This may be difficult to distinguish from malignancy, and microscopic examination of a specimen removed through the cystoscope must determine the diagnosis. Occasionally error may arise from obtaining a portion of a malignant papilloma which does not show typical malignant cells, or when through technical error a piece of the surrounding mucosa is obtained.

Cystoscopic examination may give other data of importance to the surgeon. It is of value to ascertain the location of the tumor and its relation to the ureter, if possible, in order to determine whether it is necessary to resect and reimplant the ureter. Occasionally the papilloma overlaps the meatus, and it may then be impossible to locate its base. It is also desirable to know how far the tumor is from the sphincter, since involvement of the sphincter renders resection much more difficult.

In case it should be found necessary to sacrifice the involved kidney it is important to know the function of the opposite kidney; otherwise it is possible that the better kidney of the two may be destroyed. Indigo carmin offers a rough estimate of comparative renal function and should be employed routinely in cases of vesical tumor.

Cystographic Examination.—Although cystoscopic examination may not be possible because of the patient's intolerance, or because of profuse bleeding, a cystogram of the bladder filled with an opaque medium frequently furnishes valuable data. The clinical value of

demonstrating the outline of the bladder, which is termed cystography, as an aid to diagnosis, is not fully appreciated. It may be of value in the differential diagnosis of vesical neoplasm, vesical diverticulum, and prostatic obstruction, particularly if because of excessive hematuria, intolerance, contraction of the vesical lumen, or impassable urethral obstruction a complete cystoscopic examination is impossible. The existence of a vesical tumor may be inferred from the presence of a filling defect in the outline of the bladder. The extent and character of the filling defect may also determine the size and nature of the tumor. It must be remembered, however, that partial distention of the bladder, reflex spasm, blood clots, etc., may cause error in interpretation. In inflammatory conditions of the bladder mucosa silver iodid emulsion is preferable because as a medium it is non-irritant.

Treatment.—*Fulguration.*—In 1910 Beer first demonstrated that tumors of the bladder can be removed with the high frequency current introduced through a cystoscope. He at first believed that the method would be applicable to all tumors, but, experience has demonstrated that it is only applicable to papillomas. A review of 33 cases of benign papillomas in which fulguration was done at the Mayo Clinic, and which were later observed repeatedly, showed that no recurrence was noted in 24 (73 per cent.).[2] In all but 2 of the other cases, the recurrent growth was again removed by fulguration; in these 2 malignant changes made resection necessary. Although the ultimate results following fulguration are much superior to those following suprapubic resection, the method does not always offer a permanent cure, and the patient should be observed at regular intervals. Recurrence usually takes place in from three to six months after fulguration; the site of the recurrence is near the site of the primary tumor in the majority of cases. If the primary tumor can be removed in one or two fulgurations, recurrence seldom occurs, the degree of malignancy evidently being in direct proportion to the number of fulgurations necessary to remove the tumor. Keyes has observed that following the removal of multiple tumors recurrences are usually multiple.

Removing a papilloma by fulguration usually causes inflammatory reaction in the mucosa, and the consequent edema and granulation tissue may simulate a persistent remnant of the papilloma. However, this gradually disappears in the course of three or four weeks. Occasionally, following fulguration, the mucosa of the bladder at the site of the suprapubic incision remains congested and irregularly infiltrated for a long time, and such congestion when persistent is often indicative of underlying malignancy. The area should be fulgurated thoroughly and if the congestion remains radium should be used. Slight papillomatous proliferation of the mucosa, the exact nature of which it is difficult to determine, is sometimes visible in the bladder. Such tumors are found most often near the ureteral meatuses or the internal vesical sphincter, and, although they are probably the result of a slight chronic inflammatory reaction of the mucosa, no other evidence of inflammation may be visible. They may disappear spontaneously but occasionally they remain stationary in size for several years. It

is quite possible that some of these are the forerunners of papillomas or malignant tumors; this is further suggested by the frequency with which malignant tumors are found near the ureteral meatuses. When discovered they should be removed at once by fulguration.

Malignant papillomas sometimes respond to fulguration, but they require more frequent and prolonged applications than benign papillomas. It should be stated, however, that long-continued fulguration in cases of proved malignancy may do more harm than good. Geraghty found that by first applying radium the tumors respond more readily to fulguration. If they are resected, the recurrence may be less malignant, and may respond to fulguration. The degree of malignancy is evidently reduced with successive recurrences.

Surgery.—The bladder, situated beneath the pubic bones, is not so accessible for surgical intervention as the other abdominal viscera. Instead of being covered by a layer of protective peritoneum it is almost completely encased in a fatty tissue, which offers little if any resistance to infection. The inaccessibility of the organ and the difficulty in preventing infection are the sources of trouble in surgery of this region; however, the functional results obtained, even after extensive operations, are very gratifying.

The operative procedure for tumor of the bladder consists in excising the tumor and resecting the portion of the wall of the bladder from which the tumor arises. It is possible to remove a large segment of the bladder wall and still maintain practically normal functional conditions. A simple excision of the tumor is permissible only in the case of a papillary tumor on a pedicle, and even with this form of tumor it is better to excise a portion of the adjoining tissue. Excision of the growth is not sufficient, and is no safer than resection. In all cases, the resection should include the entire thickness of the bladder. This means, of course, the invasion of the prevesical space, but with modern technic very little is added to the operative risk. If the resection has not been extensive, the opening may be closed, and drainage established through the bladder. If a large segment of bladder is removed, it is best to drain the space for several days. The drain may be brought out through or along the side of the bladder. If the prevesical tissues are exposed drainage is essential.

The transperitoneal method of exposing the bladder is not now believed to be necessary or to have the distinct advantage formerly ascribed to it. If the peritoneal side of the bladder is involved, the peritoneum should always be opened and packed off to allow a complete removal of that part of the bladder, together with the peritoneum. This requires a more extensive operation, but apparently does not increase the mortality. If anything is to be gained in exposure or in thorough removal of the neoplasm by opening the peritoneum this should be done, although usually an incision down to the prevesical tissues, making all parts of the bladder accessible, without opening the peritoneum, is sufficient, and a satisfactory resection can be made. The operation should be performed with the same precision as in the removal of malignant growths of the stomach or colon.

Unfortunately, most tumors originate in the base of the bladder and in a large percentage of cases one of the ureteral areas is involved. The most inoperable cases are those in which the urethral orifice is included in the growth, and often a total cystectomy is required, a procedure which as yet can seldom be advised.

Transplantation of one ureter to a new quadrant of the bladder may be performed satisfactorily. In a few instances both ureters have been transplanted, but this is seldom required as a tumor, even when it is extensive, usually involves only one side. If the growth completely occludes the ureter the kidney on that side probably is functionless, and in such cases, if it is difficult to make a satisfactory transplantation the ureter may be ligated. This procedure has been followed repeatedly and no ill results have been observed. In one case only was it necessary to remove the kidney later. If possible the divided ureter should be transplanted. Complete resection of the bladder for carcinoma, with implantation of the ureters into the sigmoid or lumbar muscles has been done, but is seldom advisable; a condition so extensive usually is not confined to the bladder.

At least one-half of the bladder may be removed and good function obtained. It has been suggested that these small bladders gradually increase in size until they are normal; if a very large segment is removed, however, it is probable that the size will remain diminished, as is evidenced by frequency of urination.

The most important consideration in surgery of the bladder is the preservation of the sphincter muscle at the urethral orifice. This is necessary if the patient is to maintain any degree of comfort. If the question arises of whether or not the sphincter is to be sacrificed it is best to view the condition as inoperable, for the patient will practically never be satisfied without urinary control. The only alternative is to reimplant the ureters into the intestinal tract, a satisfactory procedure in many cases as the rectal sphincter will control the urine.

If the bladder is extensively involved, particularly the base, and if resection is impossible, the use of the Percy cautery is often followed by excellent results. In the deep penetrating growth when resection or cautery is impossible, radium is indicated. This is preferably applied by means of needles imbedded into the tissue and left there for twenty-four hours or more. This should be followed later by rectal application of radium. If the tumor involves the ureteral meatus and is resected, if the ureter is found to be comparatively normal it may be cut off and implanted in another portion of the bladder. If the ureter is dilated and diseased it may be advisable to ligate and drop it back. As a result, the kidney atrophies and soon ceases to functionate, but the danger of leakage from the ureter is then obviated. The resulting clinical reaction is rarely severe; in a few days no ill effects are noticeable.

Radium.—Radium may be used either alone or as an adjunct to surgery. It may be employed to advantage at the time of operation in application to the site of the excision, in the hope of destroying

malignant cells which may have escaped excision. Extensive malignant tumors of the bladder occasionally entirely disappear after the introduction of radium into the bladder. Extensive epitheliomas involving the vagina have responded remarkably well to the application of radium in the vagina and suprapubically. The application of radium directly over the surface of the tumor by means of cystoscopic apparatus is the most rational method. Inserting into the tumor tissue needles or glass tubes containing radium emanation has also been followed by good results.

Results.—The operative mortality in cases of vesical neoplasm is necessarily high, but if all precautions are observed, it should be under 10 per cent. Watson has collected the records of 653 patients with vesical tumors, 243 benign and 410 malignant, and has found that following more or less radical operations for papillomas and myomas, 34 per cent. were free from recurrence at the end of one year. He states that if the operative deaths and the rapid recurrences are combined under the head of operative failures, such failures have occurred in 28.6 per cent. of benign tumors and in 46 per cent. of carcinomas. If benign tumors are left alone, they may cause death by extension, by repeated hemorrhage, or by pyelonephritis following cystitis. In many instances if the growth is thoroughly removed the patient recovers and remains well.

The prognosis in cases of carcinoma of the bladder is as favorable as in carcinoma of other regions, since the lymphatics in this locality are slow to become involved. There can be no question of the advisability of removing these tumors if they can be operated on when they are comparatively local. But if the growth is so extensive that it cannot be removed thoroughly, little or nothing will be accomplished by interference. The postoperative results in cases of papillomatous, flat or solid tumors differ widely, the results being much better in the papillomatous. Thus, in a recent review of postoperative results, in 82 cases of papillomatous tumors with complete data in which operation was performed at the Mayo Clinic 44 patients (52 per cent.) were alive, many of them after eight or ten years. In the 43 cases of flat or solid type of tumor, but 9 patients (21 per cent.) were alive with an average postoperative period of five years and six months. Many of those who died lived for a year or two after resection, and were comparatively well and free from the severe urinary symptoms which they had prior to operation.

BIBLIOGRAPHY.

1. Beer, E.: Removal of neoplasms of the urinary bladder. Jour. Am. Med. Assn., 1910, liv, 1768–1769.

2. Braasch, W. F.: Tumors of the bladder and their non-operative treatment. Minn. Med., 1918, i, 168–172.

3. Geraghty, J. T.: Treatment of bladder tumor. New York Med. Jour., 1916, civ, 838–840.

4. Geraghty, J. T.: The results of treatment of bladder tumors. Jour. Am. Med. Assn., 1917, lxix, 1336–1340.

5. Watson, F. S.: The operative treatment of tumors of the bladder. Ann. Surg., 1905, xlii, 805–830.

SURGERY OF THE PROSTATE GLAND.

By GEORGE E. ARMSTRONG, M.D., F.A.C.S.

ANATOMY OF THE PROSTATE.

The prostate is a glandular organ, appearing at the third month of intra-uterine life, and reaching full development at puberty. It belongs embryologically and functionally to the sexual apparatus but is of interest to surgeons largely because of its relation to the urinary system. It is found only in the male. It is about the size of a horse-chestnut, weighs 15 to 20 gms. and is placed outside the pelvic fascia in the tissue which forms the pelvic floor; *i. e.*, the urogenital floor. It lies between the rectum and the symphysis pubis between two lines drawn from the tip of the coccyx to the upper and lower margins of the symphysis pubis (Kohlrausch). It embraces the neck of the bladder and gives passage to the first part of the urethra. Its anterior surface is retained in contact with the posterior surface of the symphysis by bands of connective tissue derived from the recto-vesical fascia forming the pubo-prostatic or anterior true ligaments of the bladder. The lateral surfaces are in contact with the anterior part of the levator ani muscles. Under this fascia is found a large plexus of veins, the plexus of Santorini. The posterior surface is closely connected with the anterior wall of the rectum by dense, fat-free connective tissue in which there are no large vessels.

The urethra passes much nearer the anterior than the posterior surface of the gland. It is about 1¼ inches long and crescentic in shape. In the floor of the prostatic urethra are found a ridge called the caput gallinaginis, the colliculus seminalis or verumontanum, the sinus pocularis or uterus masculinus, the openings of the ejaculatory ducts and the orifices of prostatic glands. On each side of the colliculus are grooves, sometimes called the prostatic sinuses or furrows.

The prostate is supplied by branches of the adjacent vesical and hemorrhoidal arteries. The veins after forming the plexus of Santorini empty into the vesical veins. The nerves are from the hypogastric plexus. There is a connective-tissue capsule reinforced by unstriped muscle fibers and bloodvessels immediately surrounding the prostate and outside of this a plexus of veins, and a reflexion of the recto-vesical fascia.

The prostate is made up of a glandular tissue and a fibromuscular stroma. The muscle fibers are chiefly of the unstriped variety continuous with the musculature of the bladder wall together with a lesser quantity of striped muscle fibers. The circular unstriped bundles

of muscle common to the neck of the bladder and prostate form the internal sphincter of the bladder. The muscle fibers are continuous with the compressor of the membranous urethra or external sphincter of the bladder.

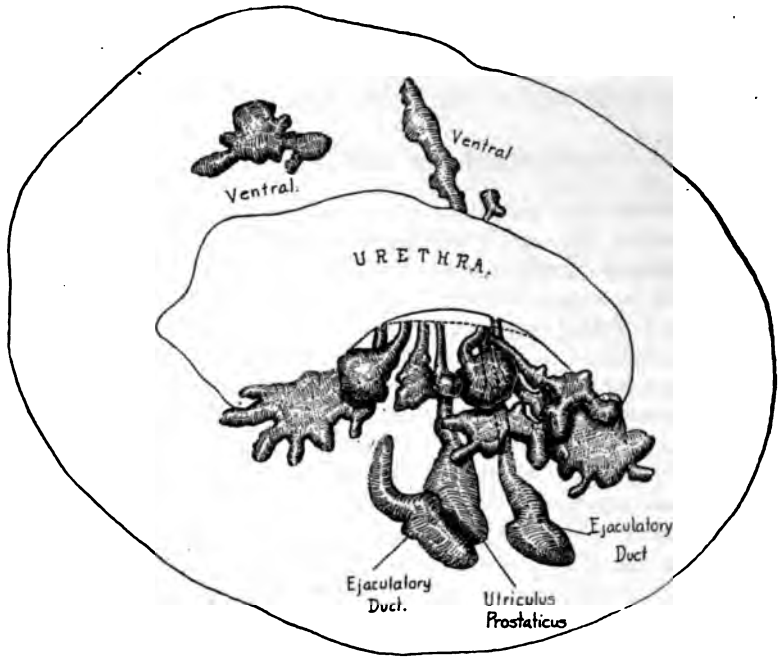


FIG. 132.—Composite drawing, showing course of tubules of the middle lobe of prostate; 12.5 cm. human fetus. Four months. × 30.

The question as to the number of lobes in the prostate is of very great surgical interest. The older observers said two. They regarded the enlarged median portion found in a certain percentage of old men as a development from one or both of the lateral lobes. This third lobe was first described by Dr. Everard Home and is sometimes called the Home lobe or median lobe. This view is supported by Pallin[1] and Jores.[2] On the other hand Griffiths[3] concludes that the middle lobe, when present, is anatomically and embryologically independent. Tandler and Zuckerkandl[4] find the middle lobe constant and report it as morphologically and embryologically independent. From their study of the anatomy of the prostate they conclude that the prostate normally consists of five lobes: two lateral, an anterior, a posterior and a middle lobe. The fifth or posterior lobe is separated from the lateral lobes by the ejaculatory ducts and seminal vesicles. Lowsley[5] has clari-

[1] Archiv. für Anat. und Physiolopie, 1901.
[2] Virchows Archiv. für Path. Anat., 1894, Bd. cxxxv.
[3] Jour. of Anat. and Physiology, 1889, vol. xxiii.
[4] Folia Urologica, 1911, Bd. v.
[5] Jour. Am. Med. Assn., 1913, vol. lx.

PLATE V

ttal View of a Wax Model of the Prostate of a Newborn Infant. × 14.

anterior branches of lateral lobes; *P.L.*, posterior lobe; *E.J.*, ejaculatory duct; *S.V.*, l vesicle; *A.L.*, anterior lobe tubule; *U.*, urethra; *U.P.*, utriculus prostaticus; *A.G.*, sub- l glands of Albarran; *M.L.*, middle lobe tubules; *L.Ur.*, left ureter; *Bl.*, bladder; *P.Gl.*, e gland.

fied this question by his study of the prostate at birth and in the adult. He examined 103 prostates obtained at autopsy from dissecting room cadavers and from fetuses and found the middle lobe present in all but 1—a fetus. The five lobes were identified. The middle lobe is composed on an average of ten tubules. The openings of these tubules are widely separated from those of the other lobes and open on the floor of the vesical end of the urethra proximal to the colliculus. The lateral lobes which make up the mass of the gland are each made up of an average of thirty-seven tubules which empty for the most part into the prostatic furrows, a few emptying on the lateral walls of the urethra. The anterior possess an average of 9 tubules which open on the anterior wall of the urethra. The posterior lobe embraces the lateral lobes like a cap. It is composed of eight tubules which open on the floor of the urethra caudad to the collicules. It presents a longitudinal depression in its under surface commonly called the median furrow.

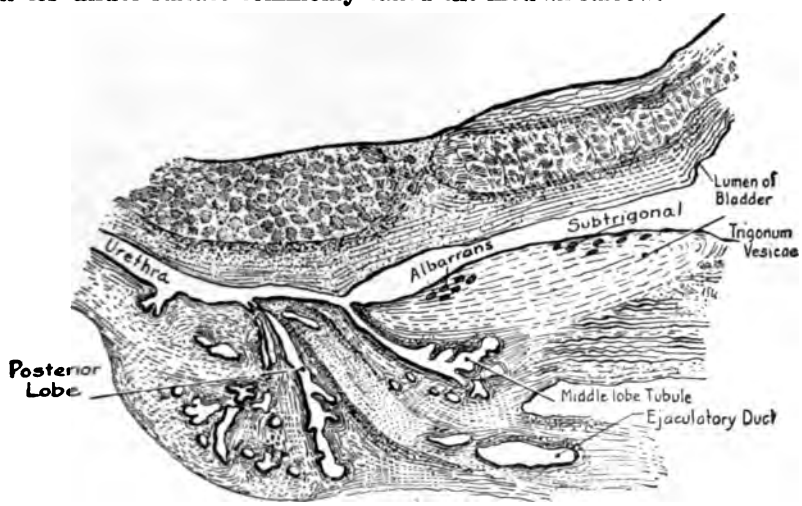


FIG. 133.—Sixteen cm. human fetus. Prostate. × 15. (Lowsley.)

There are other glands opening into the floor of the prostatic urethra. Near the apex of the prostate are the glands of Littré situated within the muscular walls of the urethra. In addition should be mentioned the subcervical group of Albarran,[1] the development of which is described by Lowsley.[2] They are situated about the middle of the posterior part of the internal vesical sphincter. They are imbedded in the submucous structure and open for the most part near the middle line of the floor of the urethra, a few opening into the beginning of the prostatic furrows. Lastly must be mentioned the subtrigonal group lying in the mucous membrane about the middle of the trigonum vesicæ. A few small branches of these tubules extend into the musculature of the bladder wall.

[1] Maladies de la Prostate, 1902.
[2] Am. Jour. of Anat., 1912, xiii, No. 3.

ATROPHY OF THE PROSTATE.

Complete absence of the prostate occurs only in association with other developmental defects in the genito-urinary system, such as anorchidia and cryptorchidism. Even more rare is the absence of one-

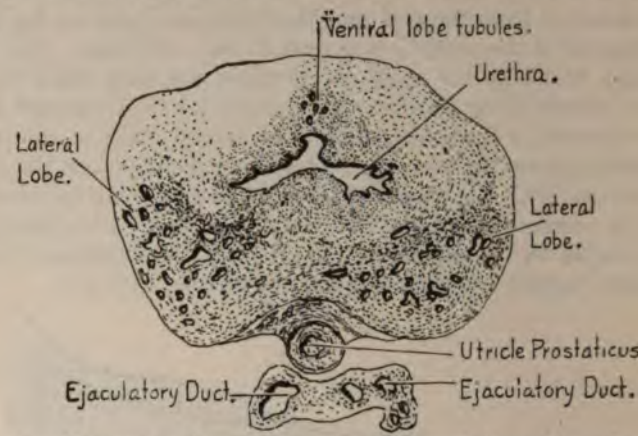


FIG. 134.—Nineteen cm. human fetus. Five and one-half months. (Lowsley.)

half of the prostate. The displacement of a portion of the prostate has been reported by Luschka; *i. e.*, a bit of glandular tissue resembling the prostate was found on the dorsum of the penis.

FIG. 135.—Thirty-six cm. (newborn) baby, prostate. × 6, camera lucida.

Atrophy of the prostate may occur in wasting diseases and occasionally in old age. It may be associated with atrophy of the musculature

PLATE VI

View of Wax Model of the Prostate of a Newborn Infant with Posterior and Most of Lateral Lobe Removed. × 14.

Lat., lateral lobe; *E.D.*, ejaculatory duct; *S.V.*, seminal vesicle; *U.*, urethra; *M.L.*, middle lobe tubule; *P.L.*, cut ducts of posterior lobe; *L.Ur.*, left ureter; *R.Ur.*, right ureter.

of the bladder wall when both the glandular and muscular portions atrophy. This may lead to incontinence without distention of the bladder, although in some cases because of reduplication of the folds of the mucous membrane retention and residual urine may be present. The prostate may undergo atrophy when the testicles atrophy. In these cases Caspar finds that only the glandular portion atrophies. If testicular atrophy occurs before puberty the prostate does not develop.

INJURIES OF THE PROSTATE

The prostate is not infrequently injured by instruments passed through the urethra. Its protected position saves it from ordinary forms of external violence. There were eight gunshot wounds of the prostate in 3174 gunshot wounds of the pelvis occurring during the American Civil War. It is occasionally injured by fragments of bone in fractures of the pelvis and by foreign bodies introduced into the rectum, and by blows on the perineum. The symptons and prognosis depend largely upon whether the urethra is ruptured or not. If the urethra remains intact the wound will heal kindly, unless infection occurs, or hemorrhage. If the former, an abscess may form and require drainage. A wound of the periprostatic plexus may give rise to serious loss of blood, but can usually be controlled by pressure and packing with sterile gauze.

If the prostatic urethra is torn extravasation of urine usually occurs and the bleeding, which is likely to be severe, may flow backward into the bladder. A perineal puncture, as recommended by Reginald Harrison, and the passing of a full-sized soft rubber catheter through the membranous and prostatic urethra into the bladder will permit the urine to escape and afford an opportunity to check further bleeding by packing gauze around the catheter.

SURGICAL DISEASES OF THE PROSTATE.

Inflammation of the prostate occurs in an acute and in a chronic form.

Acute Prostatitis.—The acute form is nearly always secondary to gonorrheal urethritis or colon bacillus infection. Other rare causes may be mentioned, such as constitutional diseases, masturbation, irritation from horseback-riding, passing of instruments, deep urethral injections, etc. The infection enters the prostatic duct openings. Usually only the portions of the gland contiguous with the urethra are involved in so-called catarrhal prostatitis. In more severe cases of follicular prostatitis the infection extends more deeply. The epithelium lining the ducts is exfoliated and suppuration occurs. Small abscesses may form. Under favorable conditions the purulent secretion escapes into the urethra, and resolution occurs. In other cases the small abscesses may unite and the deeper parts of the gland become involved, a condition known as parenchymatous prostatitis. Abscesses of considerable size may form

and in extreme and neglected cases the greater part of the prostate may be destroyed.

Diagnosis.—In the catarrhal form there is frequency and a moderate degree of strangury, the urine contains pus cells and comma-shaped bodies. On rectal examination no change in outline will be found and but little tenderness. In the follicular form in addition to the frequency and tenderness there is a greater degree of strangury and urination is painful. As a rule, there is very little elevation of temperature. When the deeper parts of the prostate are involved there is a change in the outline of the prostate as felt per rectum; it is excessively tender and defecation is painful. The patient is sick. The temperature is elevated and the tongue dry. Resolution may occur but occasionally large abscesses form and there may be complete retention. Fluctuation may be detected. Rupture may occur into the urethra or the rectum. The pus sometimes burrows extensively and has ruptured into the ischiorectal fossa, into the groin or through the obturator foramen.

Sterility may follow as a result of extensive destruction of the glandular portion of the prostate or the occlusion of the vas deferens by cicatricial tissue. Many of the cases run into the chronic form of prostatitis.

The most severe complications of acute prostatitis is infection and thrombosis of the peri-prostatic veins, a thrombophlebitis.

Treatment.—Rest in bed, salines, elevation of the pelvis on a pillow, ice or hot fomentations to the perineum, and a light diet suffice in the milder cases. All instrumentation should be avoided unless retention occurs, which should be relieved by the passing of a soft rubber catheter. It is good practice after emptying the bladder to inject a small quantity of nitrate of silver solution, 1 in 10,000. The prognosis is good except in old men with renal insufficiency, or myocardial degeneration.

If an abscess forms it should be opened preferably by an incision through the perineum in front of the rectum. If the abscess points through the rectal wall it may be opened by an incision through the rectum, the mucous membrane being first cleansed, painted over with tincture of iodine, and the gut temporarily packed above with iodoform gauze. The prerectal incision is preferable for obvious reasons. The prognosis in acute prostatitis is good save in old men with renal insufficiency and myocardial degeneration.

Chronic Prostatitis.—Chronic prostatitis like the acute form, is due to infection. In many instances, indeed, it is a sequel to the acute form. The most common infection is the Neisser diplococcus, but any chronic urethritis may extend to the lining of the prostatic ducts, and is not infrequently associated with old urethral coarctation and vesical and prostatic calculi. Again, as in the acute form, only those portions of the prostate near the urethra may be involved or the deeper parts as well or indeed the whole prostate may be affected. There may be simply desquamation of the epithelium lining the ducts or abscesses

may form, and in the later stages cicatricial tissue. Ciechanowski thinks that chronic gonorrheal prostatitis may sometimes end in prostatic hypertrophy. Prostatic abscess may rupture through the levator ani and become a pelvi-rectal abscess.

Symptoms.—There is often some frequency of micturition, especially during the day. The urine contains pus and sometimes red cells. The source of the pus is determined by instructing the patient to pass his urine. This will clear the urethra. The prostate should then be massaged and the secretion expressed collected at the meatus. A comparison of the two urines will show that the second portion contains more pus and threads than the first. Normal prostatic secretion contains the so-called sperm crystals of Böttcher or Charcot.[1] On rectal examination the prostate is found tender to the touch. If abscess forms there will be increased pain during micturition and defecation and a fluctuating swelling can be palpated through the rectum or through the perineum. Chronic prostatitis seems to bear an etiological relationship to sexual neurasthenia, particularly when there is an increase of prostatic secretion or prostatorrhea.

Treatment.—Chronic prostatitis occurs in nearly all cases of chronic posterior urethritis. In many cases it is self-limited and disappears by resolution. As it is nearly always due to the gonococcus the pus should be examined for the diplococcus of Neisser. If present the pus is infectious. The two outstanding points in chronic prostatitis are its infectivity and its frequent association with neurasthenia. The urethritis should receive appropriate treatment and the prostate treated directly by massage. These patients should always be kept under observation and treatment until the gonococci have disappeared from the pus, and the prostatic exudate proved to be sterile. If an abscess forms it must be opened and drained through a prerectal incision.

Tuberculosis of the Prostate.—Primary tuberculosis of the prostate is rare. It is generally met in young adults and in association with tuberculosis of the kidneys or epididymis. Heredity is regarded as a predisposing factor. The primary lesion may be in the lungs. Direct infection may take place from the urethra in tuberculosis of the bladder, vesicles or epididymis. Tubercle bacilli have been found by Jani in apparently normal prostates in patients suffering from pulmonary phthisis. The disease generally begins in the periphery of the gland.

Symptoms.—When the disease is limited and the urethra not involved, there may be no symptoms to direct attention to the prostate. Small foci may caseate and become calcified and small abscesses may be absorbed. In many active cases there is frequency and distress in the perineum. Hemospermia and blood-stained pollutions when present are noticed and cause the patient considerable distress of mind. In other cases bulging in the perineum is the first evidence of the disease. Occasionally tubercle bacilli may be found in the prostatic secretion obtained by massage. In advanced cases palpation through the rec-

[1] Chayce: Vol. i, p. 843.

tum discovers nodules in the prostate, some hard and some soft. Abscesses may rupture into the pelvi-rectal space, the urethra, rectum or perineum. The most serious complication is infection of the prostatic plexus of veins, thrombophlebitis and urethro-rectal fistulæ.

None of the symptoms are pathognomonic, but derive their distinctive value from their association with other tuberculous lesions.

Treatment.—In the milder cases the treatment is entirely constitutional. If an abscess forms it should be opened and drained, preferably through a curved prerectal incision, taking care to keep behind the bulb. The prognosis is not good. A persistent sinus is highly probable. Here again, rest, fresh air, and good food are indicated. The systematic use of vaccines is sometimes beneficial. Removal of the prostate is seldom indicated. Unfortunately tuberculous disease in the prostate is only too often a part of a more widely distributed tuberculous infection and prostatectomy should be considered only in those cases where the disease is chiefly a local one, and in which it would appear that material relief would follow its removal. When the pain and difficulty in micturition are very distressing considerable relief is afforded by suprapubic drainage.

Syphilis.—Syphilis in the tertiary form is said to have occurred in the prostate. It is exceedingly rare. Many specialists practicing in large centers have never seen a case. It is said to resemble a carcinoma of the prostate. If the patient is a young or middle-aged man, and has a urethral discharge containing pus cells but no gonococci, the Wasserman test should be made and, if positive, antiluetic treatment administered.

PROSTATIC CALCULI.

Prostatic calculi are formed in the prostatic ducts. They are generally small, about the size of No. 8 shot. Large prostatic calculi weighing 240 grains have been reported. In every adult prostate are found small bodies called corpora amylacæ. They consist of inspissated secretions containing desquamated epithelial cells and lecithin. They are the result of altered secretion rather than infection and are not, therefore, pathological. The phosphate, carbonate or oxalate of lime salts are sometimes deposited around these corpora amylacea, thus forming prostatic calculi. They are always multiple—a hundred or more being found in some cases—and they give a shadow under the *x*-rays. They must not be confused with calculi formed or lodged in the prostatic urethra and neck of the bladder, a condition dealt with in another section.

Symptoms.—Prostatic calculi may exist for years without symptoms. They may pass through the duct openings, or ulcerate through the mucous membrane into the urethra and be passed. There is sometimes an urethral discharge which may be sanious, and symptoms of irritation about the neck of the bladder. In rare cases they have been found in a prostatic abscess that has burst into the urethra, rectum or perineum.

When they ulcerate into the urethra they leave small areas of necrosis. Calculi deeply placed in the gland may lead to inflammatory conditions that are followed by atrophy.

Diagnosis.—The diagnosis in the past has often been made during operations on the prostate undertaken for other conditions. I found a very large number, in one case of hypertrophy, while removing the gland. They have been felt per rectum and by palpation they could be felt grating against each other. They have been felt in passing a metal sound through the urethra. Here of course, the same sensation would be conveyed by calculi from other sources lying in the urethra. A positive *x*-ray picture taken with the bladder and rectum empty would be a demonstration. Some of them do not cast a shadow. Generally they are only discovered at autopsy.

Treatment.—Prostatic calculi generally exist without symptoms and, therefore, require no treatment. If they cause pain and distress the treatment is surgical. They should be removed through a prerectal incision and the cavity drained. Abscesses should be opened and drained. There is a tendency to recurrence. The suprapubic incision should be reserved for those cases in which it is desired to remove the gland together with the calculi.

ENLARGEMENT OF THE PROSTATE; HYPERTROPHY OF THE PROSTATE.

Enlargement of the prostate occurs in about 30 per cent. of elderly men, seldom before the age of fifty. The increase in size varies from 20 to 250 grams. The benign enlargements derive their importance from the fact that the prostate gland is intimately associated with the neck of the bladder and the proximal end of the urethra, and that alterations in size and shape are generally attended by more or less difficulty in emptying the bladder and in the passing of instruments through the urethra. The nature of the enlargement has been and is the subject of much discussion and difference of opinion, which is another way of saying that it is not yet thoroughly understood. Indeed there is not a unanimity of opinion as to whether the whole or only certain parts of the gland undergo this change. Adami, who has carefully examined several prostates that I have removed, regards the condition as a hypertrophy and hyperplasia of all the tissues of the prostate—an irritative hypertrophy. Others regard it as an adenomatosis, others as a fibromatosis, and yet others as an inflammatory condition. The enlargements are divisible into two groups differing in density, some being harder and some softer. In the soft variety the glandular portions predominate and in the hard, the fibrous tissue. (The effect of the enlargement is to change the length and direction of the urethra and also the position and shape of the bladder outlet.) Tandler and Zuckerkandl, from a study of hypertrophied prostates in the postmortem room, examination of patients who had died after prostatectomy and of the prostates removed in their clinic,

conclude that only one portion of the prostate is involved in the change and that it is always the same portion, viz., the middle lobe. They find that it is the middle lobe and only the middle lobe that is removed in typical cases of prostatectomy, and that the lateral lobes having undergone compressive atrophy, remain and form what is generally recognized as the capsule. The surgical capsule has nothing to do with the anatomical capsule. Total hypertrophy of the prostate does not exist. Other parts than the middle lobe are atrophied from pressure. They also find that the enlarged middle lobe alters the vesical outlet in two different ways. In one it projects into the bladder as a wedge, stretching the internal sphincter and changing its contour; in the other simply elevating it without deformity or change of outline leaving the sphincter unchanged: A part or the whole of the hypertrophied part always lies below the sphincter. There are cases in which nodules varying in form and size are found within the region of the bladder opening but above the sphincter. These nodules they find are generally of adenomatous structure but sometimes fibrous and myomatous. These nodules differ from true hypertrophy of the prostate by their relations to the sphincter, by lack of connection with the prostate, and finally by their different histological structures. They originate from the cells of the mucous membrane and the adenomata from the glands of this region. In conclusion they state that the submucous nodules of the bladder may produce all the symptoms of prostatism and further that the excision of these submucous adenomata has only a palliative result when compared with the result of removal of a hypertrophied prostate.

Etiology.—We do not know the cause of benign enlargement of the prostate. None of the theories suggested have won general acceptance. A histological study does not confirm the theory of a neoplastic growth. The theory of the French pathologists that the enlargement is due either to a localized or general arteriosclerosis as suggested by Launois, a pupil of Guyon's is clearly incorrect. Arteriosclerosis is found without prostatic enlargement and conversely prostatic enlargement exists independently of arteriosclerosis, either local or general. The same may be said of Ciechanowski's theory that it is an inflammatory condition resulting from infection by the gonococcus or other pathogenic germs. Many men with chronic urethritis are free from prostatic hypertrophy, and men suffer from hypertrophy of the prostate who have no urethral history whatever.

Veszpréme[1] is of the opinion that the histological picture of the hypertrophic prostate shows none of the deciding points of a true new growth—an adenoma—nor do the microscopical findings prove the correctness of the theory of supposed inflammatory origin. Indeed in the few cases in which histologically the signs of a progressed chronic inflammation were found, the prostate did not have the characteristic appearance of a hypertrophic prostate, but showed rather a fibrous transformation with shrinking tendencies.

[1] Folia Urologica, 1911, Bd. v.

Adami's theory of an irritative hypertrophy and hyperplasia at least sounds reasonable; certainly not in all cases can the irritation be credited to sexual excesses, alcoholism, constipation, or a sedentary life.

Whether we accept the new pathology of enlarged prostate as set forth by Tandler and Zuckerkandl or not, there can be but little difference of opinion regarding the gross changes that occur in the urinary organs as a result of long-continued prostatic obstruction. The changes in the urethra affect chiefly the floor. The vesical end of the urethra may be raised, forming a more or less sharp curve, and in some extreme cases the vesical wall would appear to be invaginated into the urethra, causing an angulation of the urethral floor that renders the introduction of a catheter impossible. The upward or forward projection of the middle lobe may act as a ball valve and be forced into the vesical outlet during micturition. Straining efforts to overcome the obstruction only render it the more complete. The enlargement is not always uniform. The urethra may be deviated to one side or the other still further increasing the difficulties of instrumentation. It is obvious that the old rule to keep the point of the catheter closely applied to the anterior wall is well founded. The prostatic urethra is increased in length. The total length of the urethra may be increased from one to four inches.

The bladder musculature at first undergoes hypertrophy, the individual muscular fibers being found twice as broad as normal. When the obstruction is extreme, hypertrophy gives place to dilatation of the viscus and thinning of the walls.[1] Later on the muscular fibers undergo fatty degeneration and fibrosis. Trabeculation occurs. Phosphatic calculi sometimes form in the stagnant urine behind the prostate, and very considerable hemorrhage from the dilated prostatic veins is not a very uncommon occurrence.

Ureters.—The increased intravesicular tension is sometimes followed by dilatation of the ureters and pelvis of the kidney.

Kidney.—The dilated pelvis causes increased pressure in the kidney tubules, and in some cases is finally followed by an interstitial fibrosis. The renal function would seem to be disturbed by this back pressure. It is quite common to note the change of the specific gravity of the urine from 1006 or 1008 to 1015 or 1020 in four or five days after the pressure is relieved by indwelling catheter or a suprapubic drain, and the increased renal efficiency is generally permanent. In some cases if the back pressure on the kidneys is allowed to continue too long an interstitional fibrosis develops, and a double hydronephrosis. If infection is added the changes in bladder, ureter and kidney are greatly aggravated. Cystitis and ureteritis develop and the hydronephrosis is changed to a pyonephrosis. Changes in the circulation particularly a dilated and varicose condition of the veins which surround the prostate and which communicate with the dorsal veins or

[1] Adami: The Principles of Pathology, vol. i.

the penis, is not uncommon. These changes in the prostatic veins account for two complications; viz., hematuria and the transient prostatic obstruction to the outflow of urine following exposure to cold, alcoholism and excessive venery. The prostate becomes temporarily hyperemic, swollen and permeated with serum.

Symptoms.—The symptoms of enlarged prostate are essentially progressive. At first there is only a little frequency at night. It is found necessary to micturate an hour or two before the regular time for rising. A little later the patient finds it necessary to rise once or twice during the night. This is partly due to nocturnal polyuria, the cause of which is not known. Frequency during the day soon appears. With the frequency there is commonly a little delay in starting the stream, and sometimes there is an unpleasant urgency. The call to urinate becomes imperative and does not permit of delay. There may be noticed a lessened power in projecting the stream, or as the French say, "il pisse sur ses chaussures." The difficulty is increased by exposure to cold, the abuse of alcohol, sexual excess, constipation, etc. He may find it difficult or impossible to micturate while in the horizontal position. At this, which may be called the irritative period, there is sometimes an abnormal sexual desire, nocturnal erections, and in the feeble-minded, there may occur acts of impropriety. If the middle lobe projects forward and obstructs the outflow the use of the abdominal muscle to aid the contraction of the bladder wall may cause complete stoppage and these patients soon learn to avoid that action. As time goes on and the outlet of the bladder is elevated by the enlargement a certain amount of urine remains in the pouch behind the prostate after each micturition, the so-called "residual urine." Finally the bladder walls yield, dilatation takes place, and the residual urine which at first was 1 or 2 ounces may amount to 100 ounces or even more. The patient rises every hour or even every half-hour to micturate. His sleep is disturbed, he loses flesh, and strength. Finally, he can only pass a few drops at a time and the urine dribbles away between the acts of micturition, the overflow and incontinence of retention causing fatty and fibrous degeneration of the musculature of the bladder wall. Finally no urine at all can be passed. If infection is added to the above symptoms the pain, frequency and distress are increased. As a result of the cystitis, calculi may form in the bladder and an ascending uretheritis and pyelitis endanger the patient's life. Prostatic abscess is a rare complication but severe hemorrhage from rupture of a prostatic vein is not uncommon.

Acute attacks of complete retention are not infrequent. In fact such an attack is sometimes the first sign of an enlarged prostate recognized by the patient. These intercurrent attacks of complete retention are more common among what are called hospital patients. They generally follow exposure to cold or a drunk. The suffering from vesical spasm is often extreme. The obstruction is due to swelling and edema of the prostate. Epididymitis may develop before or after catheterization. Chronic urinary intoxication sometimes develops even

in the absence of renal insufficiency, if the urethra or prostate are injured during instrumentation.

Diagnosis.—The history of increasing prostatic enlargement is generally very suggestive. The general health remains good until renal insufficiency appears as the result of back pressure on the kidneys, or until infection occurs. Renal insufficiency is indicated by headache, lassitude, thirst and anorexia. The health in the later stage is also impaired by the loss of sleep due to nocturnal frequency and polyuria. The degree of obstruction and the severity of the symptoms are not closely related to the size of the enlarged prostate. Rectal examination generally finds the prostate enlarged, although this is not always the case as there may be a marked middle lobe obstruction without much enlargement of the rectal surface. On the other hand, marked enlargement of the rectal prostate may be present without vesical obstruction. During a rectal examination not only the size but the hardness, the presence or absence of nodules and the mobility of the rectal mucosa over the prostate should be noted, and also whether or not the central longitudinal furrow is present or absent. The enlargement may be greater on one side than on the other, or one side may be softer than the other. A catheter should be passed to find the length of the urethra, 7 to 12 inches, and the amount of residual urine if any, *i. e.*, the amount remaining in the bladder after the patient has passed all that he can.

Cystoscopy, when feasible, reveals the vesical projection of the middle lobe, the condition of the bladder, the presence or absence of trabeculæ and diverticula, and of calculi.

A differential diagnosis must be made between chronic hypertrophy of the prostate and paralysis of the bladder due to disease, or injury to the spinal cord, vesical tumors and malignant disease of the prostate. Vesical tumors can be seen with the cystoscope. Disease of the spinal cord may be recognized by the history and other signs of disease of the cord, by the involuntary overflow and the failure of the bladder to expel the urine through a catheter. In malignant disease the longitudinal furrow on the rectal surface is often obliterated and there are hard nodules. Pain is a conspicuous symptom and generally metastases especially to the intraperitoneal glands.

Prognosis.—Chronic hypertrophy of the prostate is a progressive condition not materially influenced by drugs. A moderate diet, and regular habits by contributing to a bland urine are helpful. If concentric hypertrophy occurs (contracted bladder) frequency and strangury disturb the patient, both day and night. Excentric hypertrophy or a large diverticulum lessen frequency and add to the patient's comfort. Uremia and urosepsis are the final complications.

Treatment.—As stated above, regular habits, a simple dietary from which spices and highly seasoned food are eliminated, out-of-door exercise, and avoidance of cold, bicycling and horseback riding accomplish a great deal. Many prostatics are thus enabled to live for years in comparative comfort. Indeed in many cases of enlarged prostate

there are no symptoms and no treatment is required. For the acute complete obstruction due to congestion and edema, hot sitz-baths, heat to the hypogastrium and perineum together with purgation and morphin or heroin suppositories are our best remedies. If these fail and a catheter cannot be passed, suprapubic aspiration of the bladder should be performed without delay. The treatment of the ordinary prostatic who comes for the relief of frequency and vesical discomfort may be symptomatic or radical. The symptomatic treatment consists in the more or less regular use of the catheter, and the radical, the removal of the obstruction. Other remedies have been tried but are for the most part given up as tried and found wanting. Organotherapy, castration, vasectomy, cauterization of the prostate, have each had their advocates but are now relegated to "dry as dust" literature.

It has been said that when the residual urine amounts to two ounces the question of treatment should be seriously taken up. The method to be recommended, whether symptomatic or radical, depends in great part upon the general condition of the patient, and especially upon the functional value of his kidneys and the condition of his myocardium.

There are very few exceptions to the rule that the beginning of catheter life is the beginning of the end. The reason is that catheter infection of the bladder will almost certainly occur sooner or later, and generally sooner. I am quite familiar with the two great exceptions to this rule. There is the born ritualist, who does everything, everytime exactly as he is told to do it. One of these gentlemen has been under my observation for eighteen years. He leaves his home every morning with two sterilized catheters wrapped up in a sterilized towel, with a small bottle of sterilized lubricant. At a certain hour in the morning and again at a certain hour in the afternoon, he washes his hands as carefully as a surgeon preparing for a major operation, and uses his catheter. He never omits or varies a detail. He could not if he tried, and he is in perfect health. The other exception is the jolly old sinner who pulls a rough, cracked old catheter out of a dirty pocket, spits on it and passes it, and he is also in good health. He is immune. These exceptions, however, only prove the rule that the routine use of a catheter is soon followed by cystitis.

Reference has been made to the treatment of acute complete obstruction. There is also a condition of almost complete chronic obstruction that deserves mention. The bladder is greatly distended, extending upward to the navel or higher. The urine is perfectly clear and of low specific gravity. There are here two dangers to be recognized and avoided if possible: One is infection of the bladder and the other hemorrhage from the sudden removal of pressure from the prostatic veins, either of which may be followed by the death of the patient in twenty-four to ninety-six hours. Infection may be avoided by the careful cleansing of the pendulous urethra by irrigation, using a small catheter passed well back and allowing the hot boracic solution or other antiseptic lotion to flow forward, thus securing a return flow.

A sterile soft catheter of suitable shape should then be passed. Only a portion of the urine should be removed that the sudden alteration of pressure may not be too great. A couple of ounces of nitrate of silver solution 1 to 5000 should be injected into the bladder and allowed to remain as advised by Rovsing. The silver solution inhibits infection. Finally a urinary antiseptic such as urotropin should be administered if the urine is acid. This procedure must be followed daily or oftener, withdrawing more urine each time, until the bladder is emptied. By strict observance of these details urosepsis and hemorrhage may generally be avoided. If the patient's condition permits, the radical operation, the removal of the prostate should be considered. Two questions should be answered in the affirmative before prostatectomy is recommended. Is the myocardium good enough to carry the patient through a major operation, and the subsequent convalescent period? Are his kidneys good enough to ensure him against death from renal insufficiency? In patients for whom the answer to these two questions are satisfactory prostatectomy should be advised and the mortality will be small. The age of the patient is no bar to the operation. The two routes, the suprapubic and the perineal, have each their advocates.

The suprapubic route was advocated at the Leeds meeting of the British Medical Association in August, 1889, by A. F. McGill, F.R.C.S. He claimed "that the prostatic enlargements which give rise to urinary symptoms are intravesical and rectal and that the treatment to be effectual should for a time thoroughly drain the bladder and permanently remove the cause of the obstruction." Although a pioneer in this work he was preceded by Belfield of Chicago, who successfully removed a middle lobe of the prostate by the suprapubic route in October 1886. McGill taught that "the prostate should be removed as far as possible by enucleation with the finger and not by cutting. The mucous membrane over the projecting portion having been snipped through, the rest of the operation is completed with finger and forceps. In this way excessive hemorrhage is prevented. Hemorrhage is best arrested by irrigation with water so hot as to make it unpleasant for the hand." Mr. P. J. Freyer has adopted this method of removing the prostate and has performed the operation in a large number of cases. The interesting discussion that followed Freyer's claim that he removed the whole prostate in its capsule, is summarized in two papers by Mr. Southam and Sir William Thomson, published in the *British Medical Journal*, April 18, 1903. The studies of Tandler and Zuckerkandl already referred to, throw additional light on the question of whether the whole or a part of the prostate is removed in the ordinary operation for enlarged prostate.

In the suprapubic operation the bladder should be washed out with a mild antiseptic solution and then, except in the case of small contracted bladder, be distended with the solution used for irrigating or with air sufficiently to make it distinctly palpable above the pubes. This preliminary filling guarantees, as a rule, the elevation of the peritoneum above the field of operation. This point, however, should always be

investigated and proved before opening the bladder, as occasionally the peritoneum seems to be fixed low down. Judd prefers to open the bladder when it is empty, thus avoiding infection by the water passing out of the incision. An incision about 3 inches long is made in the middle line, immediately above the symphysis and the anterior wall of the bladder quickly exposed. Two strong catgut or silk sutures are then inserted, one on each side, by means of a round curved needle to act as retractors. A sharp pointed scalpel is thrust through the

FIG. 136.

bladder wall and the opening is enlarged sufficiently to admit the finger. The operator should then determine the size, shape, consistency and general outline of the vesical prostate; also note the presence or absence of calculi, diverticula, the degree of trabeculation and the general condition of the bladder wall. If calculi are present they should be removed.

The mucous membrane is easily divided by the finger passed into the urethral orifice and pressed forward on one side or the other.

The finger then presses backward and inward and enucleates the prostate. The large soft prostates are easily separated. The dense hard prostates are more and more difficult in inverse proportion to their size. In the case of very small dense glands in which the connective tissue predominates, it is sometimes wiser and safer to remove only the part pressing upward and obstructing the outflow.

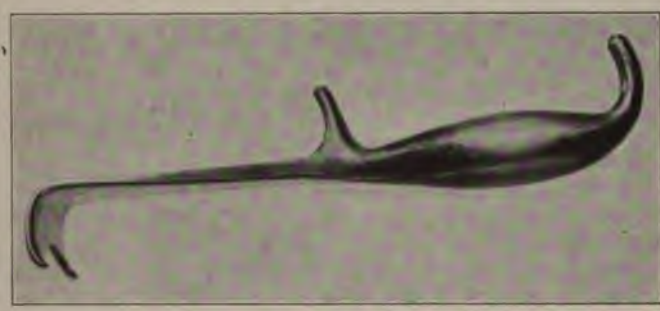


FIG. 137.

Two-stage operation. The complete operation should not be undertaken in one stage when the specific gravity of the urine is below 1012 or 1015. Low specific gravity indicates that the kidneys have suffered from back pressure and therefore that the blood serum is loaded with solids that should have been removed by the kidneys. Frequent catheterization, continuous catheterization or a suprapubic drainage is generally followed by marked increase in the specific gravity in three to five days, and the improvement is generally permanent.

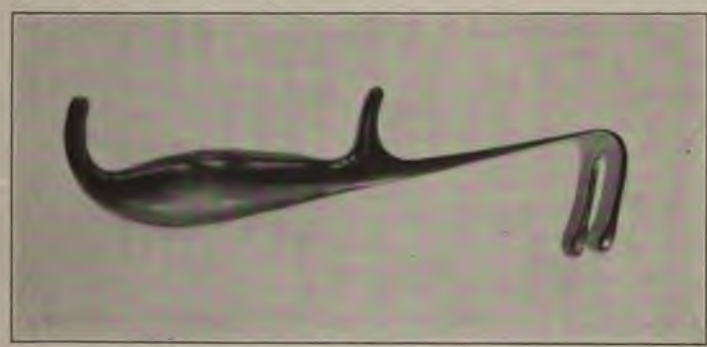


FIG. 138.

The specific gravity will rise to 1015 or 1020 or over when the prostate may be removed with safety, if the general condition and particularly the myocardium approaches the normal. If there is a foul cystitis present or large diverticulum filled with dirty evil-smelling urine, or a large quantity of residual urine the bladder should be drained and lavaged for some days before removing the prostate.

The bleeding may be controlled by pressing the capsule down the space previously occupied by the prostate. A good-sized ru drainage tube should be left in the bladder and retained in pos by a suture for forty-eight hours. If the bladder is dirty, contin

FIG. 139.—Opening up space on each side of central tendon for conservative or operation. (Young.)

irrigation with a solution of oxycyanide of mercury, 1 to 5000, sh be employed for four or five days. The tube should be remove the third or fourth day; in a clean bladder in forty-eight or seve two hours, and the opening allowed to close. The writer has five or six years suspended the bladder by attaching the bord

the bladder incision to the sheath of the rectus muscle. In this way the trigone is brought forward, the prostatic pouch elevated and a better functional result obtained with practically no residual urine. In a two-stage operation these sutures are placed in position at the end of the first stage. The average time of closure of the suprapubic

Fig. 140.—Bifid retractor inserted. Division of central tendon and recto-urethalis muscle beneath it. (Young.)

wound is sixteen days. The space from which the prostate has been removed is roofed over by the base of the bladder and lined with mucous membrane that shows but little tendency to contract Walker,[1] who holds that he removes the whole gland in the ordinary

[1] L'Association Internationale d' Urologie, 1911.

suprapubic operation, examined 50 of his cases with a view of determining how the urine was prevented from escaping. The constrictor urethræ was the effective sphincter of the bladder in 24; the sphincter vesica had resumed its normal function in 26. Micturition is generally normal. The act is preceded by the normal sensations, and the stream starts without delay.

The genital function is very little disturbed in 70 per cent. of cases. In those rare cases where the enlargement has been attended by abnormal sexual desire, which may have been one of the reasons for consulting a surgeon, the desire is lessened. In some cases the removal of the prostate has been followed by increased power. The patients who are usually old men are generally losing their virility before the operation, and commonly note little if any difference afterward.

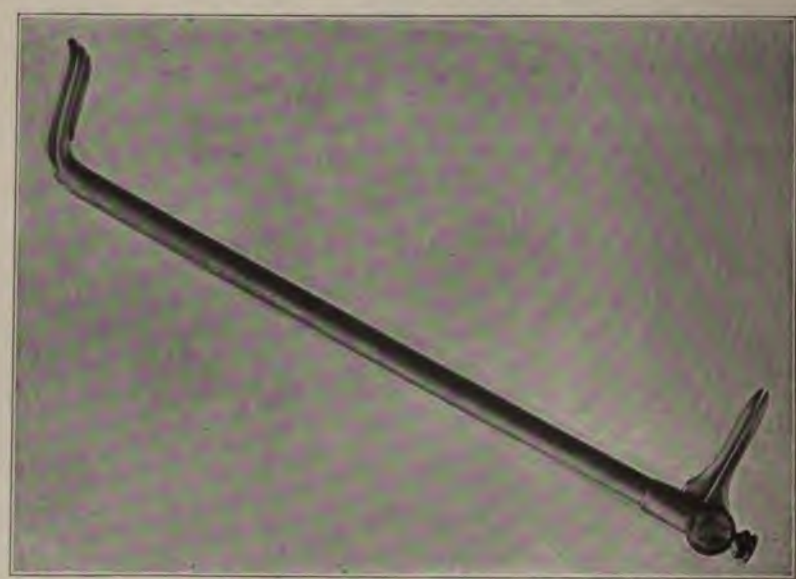


FIG. 141.—Young's prostatic tractor closed.

It is noteworthy that those who think that they remove the whole gland in the ordinary suprapubic operation very seldom find trace of the ejaculatory ducts in the parts removed.

Preoperative cystitis generally improves and is always more amenable to treatment. The restoration of the bladder muscle to its full vigor is one of the most striking results of prostatectomy. The postoperative formation of vesical calculi depends upon the persistent cystitis and the sacculation of the bladder wall. Suprapubic fistula and hernia of the suprapubic scar have been noted, but rarely. Narrowing of the bladder outlet seldom follows the suprapubic operation.[1]

[1] Wallace: International Urotropical Association Congress, London, 1911.

Perineal prostatectomy is advocated by Young,[1] of Baltimore, who thinks that it possesses advantages over the suprapubic route. His technic is similar to that of the French school elaborated by Proust. The smaller enlargements may be removed by a median longitudinal incision. The transverse curved incision with convexity

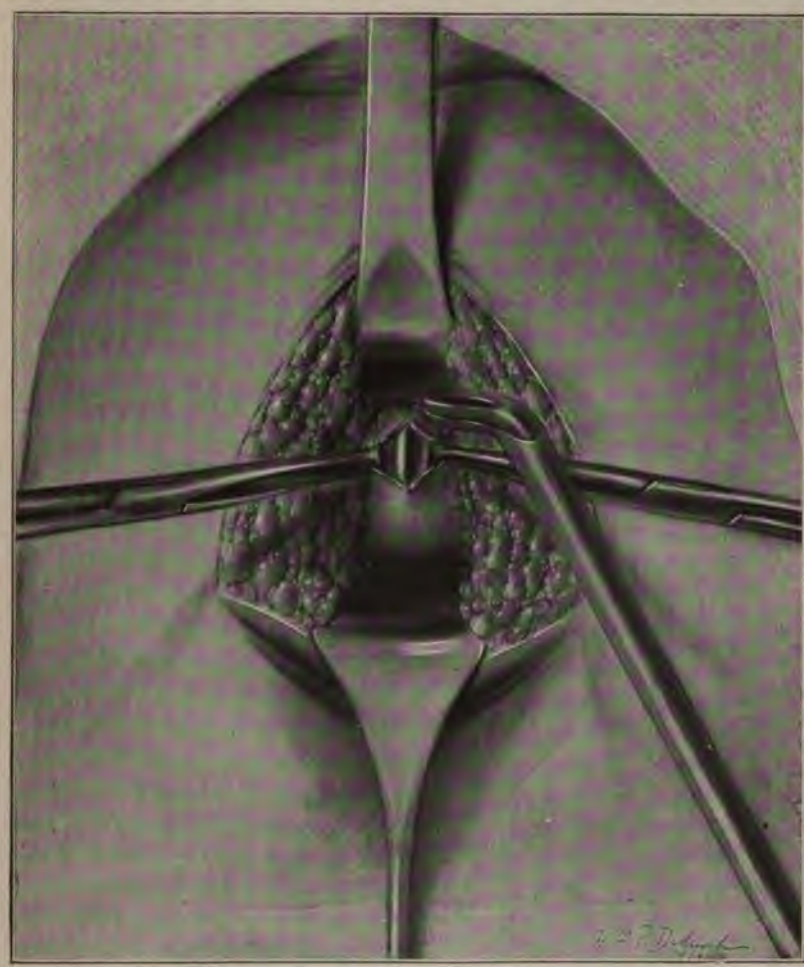


FIG. 142.—Membranous urethra opened on sound, edge caught with clips, tractor about to be introduced. (Young.)

forward gives more room. After the prostate is exposed the capsule is opened on each side by an incision parallel with the urethra. A prostatic retractor brings down the prostate and facilitates its enucleation. In Young's cases the fistula closed in 56 per cent. of the cases in less than twenty-one days. In only 27 cases out of 450 did the fistula

[1] International Urological Association Congress, London, 1911.

persist longer than the third month. In 5 cases the fistula was still present after a long period. Three of these were pauper cases and received no treatment after operation. In the 2 other cases small fistula were present two years after operation. The urinary and sexual functions after perineal prostatectomy are good. Young reports that in only 4 out of nearly 450 cases was there retention of urine requiring catheterization several times a day. Young had 17 deaths in 450 cases of perineal prostatectomy for benign enlargement, or 3.77 per cent., Walker had 6 deaths in 112 suprapubic operations or 5 per cent.

FIG. 143.—Prostatic tractor opened, as in operation. (Young.)

The contra-indications to the radical operation are a general condition of the patient unfitting him for any major surgical operation, particularly myocardial degeneration and disease of the kidneys.

A small hard fixed prostate is difficult to remove and the mortality is high. In such cases it is sometimes better to be content with a permanent suprapubic drain.

Cicatricial contraction of the bladder outlet is uncommon. Cystitis may persist for a time and demand appropriate treatment. The mortality after the removal of the prostate is getting less and will become lower as the technic is improved and as cases suitable for the medical operation are more carefully selected. The 5 per cent. mortality that obtains at present includes cases operated on with dirty bladders, damaged kidneys and impaired hearts. From now on we may expect prostatics to apply earlier, while their general condition is good and their bladder clean. It would not seem too optimistic

to expect in the near future a mortality rate of 1 per cent. in benign cases.

The suprapubic route is more generally employed than the perineal in the older countries as well as in America. The newer pathology favors it. There is very little disturbance of the urinary or sexual functions, the wound is less exposed to infection, hemorrhage is well under control and there is no danger of a permanent urinary fistula. Gas and oxygen anesthesia are satisfactory. Caird of Edinburgh speaks favorably of spinal analgesia in prostatectomy.

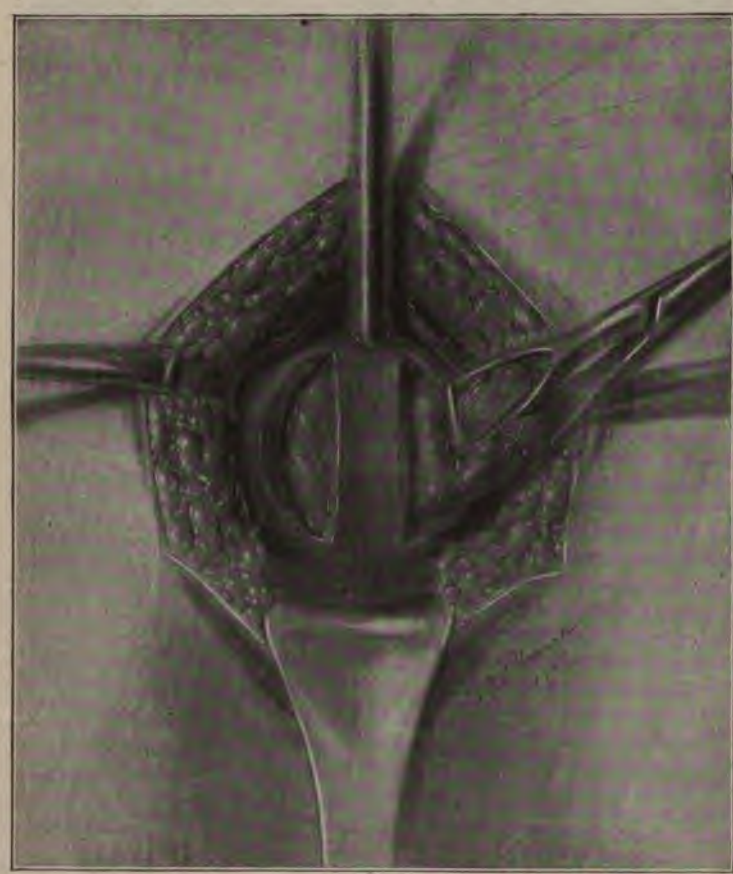


FIG. 144.—Incision of capsule and enucleation of lateral lobes. (Young.)

MALIGNANT DISEASE OF THE PROSTATE.

It is estimated that malignant disease is present in 15 per cent. to 20 per cent. of enlarged prostates in old men. Sarcoma is rare. It sometimes occurs in children and is of rapid growth. It may press upon the ureters and cause obstruction. Metastases occur to the lungs and other organs. It is always fatal.

Cancer of the prostate is generally primary and usually begins in the posterior lobe. There are exceptions to this rule as shown by a case recently in the Royal Victoria Hospital. The pathologist found no evidence of disease in the posterior lobe but definite cancer in one of the lateral lobes. There is no evidence that a benign hypertrophy changes its character and becomes malignant. Pathologists are generally of the opinion that cancer of the prostate is cancer from the start. Possibly the existence of a benign hypertrophy may favor the

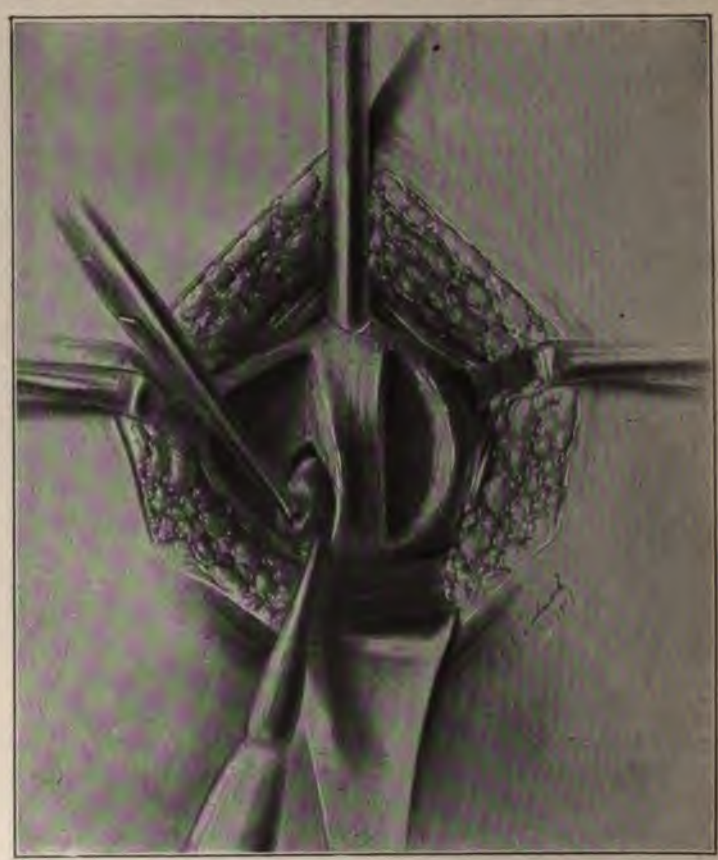


FIG. 145.—Excision of infiltrated median bar. (Young.)

development of malignant disease. Cancer of the prostate is associated with benign enlargement in 50 per cent. of the cases. Cancer of adjacent tissue may spread to the prostate particularly from the rectum, although here there is reason to think that Dénonvilliers fascia, a prolongation downward during fetal life of a fold of peritoneum between the rectum behind and the prostate and seminal vesicles in front, acts as a protective barrier. Metastases from other organs to the prostate occur in a comparatively small percentage of cases. The majority of cases occur in men between sixty and eighty years of age.

The growth spreads upward along the seminal vesicle and ureters. Young says that the mucous membrane of the urethra and bladder is not commonly involved, although cases where this has occurred have been reported by Frisch.

Metastases take place from the prostate to the pelvic and iliac lymph nodes, and also to the skeletal bones and internal organs. In this respect there is a striking similarity to the metastases occurring from the breast and the thyroid gland. Cancer of the prostate may be

FIG. 146.—Removal of rounded median lobe through the left lateral cavity. (Young.)

of the hard scirrhous variety, or soft medullary carcinoma. There are three distinct clinical types. The more common is hard and nodular, and in the early stages not easily distinguished from chronic enlargement, unless accompanied by an unusual degree of pain not relieved by micturition. In many cases the malignancy is discovered only after removal. In more advanced cases pain and perineal distress arouses suspicion and the finger in the rectum discovers hard nodules running in the direction of the seminal vesicles and toward the pelvic wall. The median furrow may be obliterated. In the second group

the disease spreads rapidly. Metastases to the pelvic glands occur early and little can be accomplished in treatment.

In the third group a general carcinomatosis with metastases to the bones would appear to develop from a small and comparatively insignificant malignant nodule in the prostate. Histologically these secondary growths resemble the structure of the prostate.

FIG. 147.—Lateral cavities in prostate packed with gauze. Tube drain of bladder through membranous urethra. (Young.)

The prognosis after removal in the first group of cases is good. Many patients are alive and well three and four years after operation and several eight and ten years after. In the second and third groups the prognosis is extremely grave and operation is contra-indicated. Double nephrostomy or ureterostomy has been suggested by Fuller to relieve the discomfort occasioned by the urine entering the bladder. When the lower ends of the ureters are occluded by the new growth life may be prolonged by this means for two or three months. Radium has not proved to be of any material value in carcinoma of the prostate. Extensive resections of the malignant prostate, the seminal vesicles, the vasa deferentia and the trigone of the bladder have been made, and it is stated that some of these patients are alive three years after

operation. Further experience is required to establish the justification of these operations.

FIG. 148.

CYSTS OF THE PROSTATE.

Our knowledge of cysts of the prostate is derived chiefly from the researches of English. They are all retention cysts. The edges of the sinus pocularis may be adherent, a condition analogous to the adhesions of the prepuce to the glans, and give rise to a cyst of the sinus pocularis. It is suggested that retention in the newborn may be due to this cause and that the passage of the catheter ruptures the cyst and incidentally separates the edges of the sinus. In a recent case a man fifty-four years of age was admitted to my ward in the Royal Victoria Hospital, suffering from almost complete retention of urine. The cause was found at operation to be a cyst of the verumontanum. The vesical end of the urethra was dilated sufficiently to admit the end of my finger to the first joint. There was no enlargement of the prostate. Enucleation of the cyst was followed by complete recovery. Other cysts due to

embryonic remnants may occur, as also dermoids, echinococcus cysts and hydrops of the seminal vesicles. They are sometimes removed by one or more punctures and sometimes by enucleation.

NEUROSES OF THE PROSTATE.

Three forms of this often troublesome condition are recognized, viz., a hypersensitive condition of the gland itself, of the mucous membrane lining the prostatic urethra, and lastly a spasmodic irritability of the musculature of the prostate that in part forms the vesical sphincter. These conditions generally exist together and are sometimes a part of a general neurasthenia.

When the gland is involved the patient complains of a weight in the perineum and the gland is found to be tender on rectal examination although not enlarged. When the mucous membrane is involved the sound causes pain on entering the prostatic urethra and the patient may faint. Spasmodic irritability of the musculature of the gland is the more common form. The patient has difficulty in starting the stream. In the milder forms this is noticed only when trying to micturate in the presence of others, but in the same type he may have occasional difficulty when alone. There is sometimes a moderate degree of strangury and there may be a little residual urine, the amount varying from time to time. There is no pus and no threads are seen in the urine. The urethra is not lengthened.

Neuroses of the prostate are generally observed in young men who have masturbated, indulged in sexual excesses, suffered from gonorrhea, or who have worked and worried beyond their strength.

Treatment.—Treatment consists in attention to the habits of the patient, their diet, and local treatment. Any inflammatory condition should receive appropriate treatment. Full-sized cold sounds passed once a day are often of great help. Constipation, if present, should be relieved, and a general tonic regime advised. Hot sitz-baths at a temperature of 100° F. are sometimes useful, and relief in other cases is obtained by the application of cold to the perineum.

PARASITES IN THE PROSTATE.

The echinococcus is often found between the bladder and rectum and cases of echinococcus cyst of the prostate have been reported. Disturbance and difficulty in micturition are prominent features. In the reported cases there has generally been found, on examination, a large fluctuating cyst in the neighborhood of the bladder, not removed by catheterization. The tumor can sometimes be palpated by one finger in the rectum and a hand in the suprapubic region. The fluid withdrawn by puncture shows scolices or single hooklets. The appropriate treatment is surgical.

THE DIAGNOSIS AND TREATMENT OF PELVIC INFLAMMATORY LESIONS.

By JOHN G. CLARK, M.D.

Nearly all of the major surgical methods of treatment have undergone during their evolution remarkable variations from radical to conservative principles or the reverse. While all therapeutic measures must at first be more or less experimental, their final confirmation, modification in detail or complete rejection is reached only by a careful analysis of results. The best surgeon is inherently conservative, for he realizes that in the excision of a tissue or an organ he does not restore it to its integrity but clears away pathological débris which is prejudicial to health or actually threatens a life. He therefore vindicates the highest principles of his art when, by judicious treatment, and withholding an operation, he restores to normal a lost or disordered function. The history of the treatment of inflammatory diseases of the pelvic organs has witnessed, during the last decade, a noteworthy change from a radical to a conservative policy.

Twenty years ago the diagnosis of salpingitis, or pyosalpinx carried with it the conviction of direct danger, and immediate surgical intervention was urged. During this era the clanging gong of an ambulance hurrying a patient to a hospital, suffering with a pyosalpinx, was a signal for an emergency operation. Now how changed is this policy, for the acute pelvic inflammatory diseases are almost invariably conservatively treated.

Vividly do I recall the narrative by Professor Freund, of Strassburg, of the history of several cases of pyosalpinx, which were held under observation in his wards prior to 1898. Under conservative treatment, to his astonishment, peritonitis did not develop, and yet, more astounding, the patients so far recovered as to be free of pain, or even of discomfort, and were returned to the out-patient department or to their homes as ambulatory cases. Such a course appeared very hazardous, and even Freund withheld publication of his observations, for he felt that this conservative attitude was too suggestive of baseless experimental medicine.

The last decade has witnessed the vindication of Freund's forecast, for now no one thinks of operating in the case of an acute pyosalpinx before the stage of subsidence has passed and the inflammatory products are reduced to quiescence, or the infection has progressed to the formation of a considerable collection of pus and surgical measures must, of necessity, be invoked for its evacuation. In this

change a splendid reduction in mortality has been achieved, and usually one or both ovaries may be conserved.

Recent discoveries relative to the function of the ductless glands have impressed us anew with the importance of preserving all tissues which elaborate an important secretion. Clinical observations have long since pointed out the dangers of ovariotomy in young women. It is not merely a stormy surgical menopause that plays havoc with the patient's nervous equilibrium, but serious metabolic changes are affected which lead to more or less ineradicable tissue transformations. In subsequent pages this prefatory statement regarding surgical treatment will be further elaborated.

Pelvic inflammatory lesions for clinical purposes may be divided into two classes: those produced by the gonococcus and those arising from other pyogenic organisms, of which the streptococcus stands as the most lethal representative. These two types of infection reach the internal generative organs through the natural atrium, the vagina, but in their pathological effects follow very divergent paths.

A third type, the tuberculous, is more frequently a descending or hematogenous infection. Because of its insiduous nature, and as it gives rise to the so-called cold abscess, its symptoms are of a less acute character. On account of the radical difference in the route of extension, and because of the difference in the lesions produced, each of these types of infection must be considered separately, and upon their proper differentiation depends so much the judicious treatment of the case.

TYPE OF INFECTION.

The Gonococcus.—This is now regarded as a typically specific organism, for it has acquired characteristics that take it out of the ordinary pyogenic class, and that stamp it with unique attributes, making it easily distinguishable in its biologic characteristics from all other microörganisms. Among the peculiarities that mark the gonococcus is the fact that it is difficult to cultivate on artificial media, whereas in its normal habitat, the mucous membrane of the genito-urinary tract, it grows with great vigor. In epithelial investments of the stratified variety it does not colonize, and therefore sets up, at most, only a transitory inflammatory reaction, which is never of a chronic nature, except when it attacks the vagina of young children and occasionally those of pregnant women. When cultivated artificially its virulence can be steadily diminished, but when this "denatured" organism is again implanted on a mucous membrane it will in one generation manifest all its original specific virulence. The organism may remain latent for months or even years, and then quickly spring into great activity, or it may remain so inactive as to give rise to no appreciable symptoms, and yet may cause an ophthalmia neonatorum in a child born of a mother so infected. Two persons—as, for example, a man and his wife—may become immune to a coincident infection, but should

cohabitation cease for a few months and then be resumed, either individual may contract an acute infection from the other, which attack will run the usual course and terminate in a pyosalpinx or again subside into a latent state. Although the gonococcus is almost always found in the superficial structures it is extremely difficult to eradicate it by medical means. It seldom kills by an acute process, but, because of its persistence, it renders thousands of women chronic invalids.

The germicidal power of the vaginal and uterine secretions, which acts with such potency in destroying other pathogenic organisms, is apparently powerless to hinder the growth of the gonococcus even in the slightest degree. In the endometrium it colonizes beneath the superficial columnar epithelium, and yet in spite of active local treatment directed to the site of infection it is only eradicated with extreme difficulty. In one case the organism may migrate with great rapidity from the cervix to the tubes and ovaries, causing serious injury to or entirely destroying the tubes in a very short time; in another case it may remain localized in the cervix for years without giving rise to subjective manifestations other than a persistent leucorrhea. A woman so affected may suffer little or no inconvenience from the disease itself, and yet may serve as a carrier of infection and be the means of transmitting an acute infection to scores of innocent individuals.

Although the toxic by-products of the gonococcus may set up a very active pelvic peritonitis, the infection seldom spreads to the general peritoneum, and but rarely causes a lethal peritonitis. The gonococcus, following, as it does, very definite laws in its action, may therefore be classified as a specific entity. Because of this bizarre action, and the many inconsistencies that accompany its course and that follow in its wake, gonorrhea in women presents a very difficult study, and much must still be learned before we can boast of our ability to cure the disease. A terse phrase or an epoch-making summary of findings and results may so dominate the historical era of a disease as actually to obstruct progress. Thus we have passed from the period in medical history a few decades ago, when gonorrhea in women was of so little apparent significance that it was mentioned only to be dismissed as unimportant. According to the former concept a woman might transmit the disease, but the man suffered from its consequences. From this attitude of indifference the medical world was suddenly aroused by Noeggerath, who, in 1872, in an epoch-making monograph of the most revolutionary character, presented the most startling facts. Regarded from Noeggerath's viewpoint, gonorrhea was one of the most serious diseases from which a woman could suffer. As a result of this paper the adage arose, "Once infected, always infected." Just as John Hunter's remarkable experiment—the production of a syphilitic chancre on his own person by inoculation with supposed gonorrheal pus—apparently proved that the syphilitic and the gonorrheal virus were identical and thus fixed

the identist theory for more than a generation, so, possibly, the epoch-making position taken by Noeggerath, and which has in many ways proved to be so correct, may now tend to overawe us and render us cowards in an attempt to cure certain stages of this disease.

THE ANATOMIC ROUTE OF INFECTION.

Gonorrhea, in its ascending progression, first attacks the vulva. Because of the flat or pavement epithelium that lines this part of the generative tract, and which is not a suitable propagating soil, the infection seldom produces more than a fleeting inflammatory reaction. In young children and in pregnant women, however, a very acute attack of gonorrheal vulvitis may occur, and in the former the process may tend to become so persistently chronic as scarcely to be eradicable. In such cases the colonies of gonococci lodge beneath the moist, delicate pavement epithelium, setting up a persistent inflammation. In the adult, as a rule, during the acute attack the skin of the vulva becomes very much reddened or even edematous, the labia minora, the clitoris, the meatus urinarius and the remains of the hymen becoming markedly swollen and very tender. The parts are bathed with pus, and, as a result of the irritation produced by the acrid discharge, the thighs and adjacent surfaces become chafed and painful. In some cases superficial erosions are present, and these may become ulcerated, especially in those cases in which cleanliness is not observed. In such cases the specific organisms are present in great numbers. The symptoms are similar to those of an acute inflammation in any other part of the body, namely, heat, redness, swelling and severe pain. Frequent and painful urination is a constant symptom. With rest and the application of simple external washes the attack quickly subsides, and in one or two weeks the parts have returned to the normal.

Urethritis.—In over 90 per cent. of all cases of gonorrhea of the generative tract the urethra is primarily involved. As a rule it is the site of the initial infection, but occasionally the urethral involvement is secondary to a cervical infection, arising as the result of contamination by the vaginal discharge. The meatus appears swollen and the mucous membrane frequently projects through the orifice in the form of an ectropion, through which a thick, yellowish pus exudes. The attack may be of a very fleeting character and is attended by by dysuria and vesical irritability, which soon subsides, and, like the vulvitis, the acute urethritis is soon over.

If the urethral inflammation becomes chronic and the hidden crypts of Skene's tubules become infected the process may continue indefinitely, manifesting but slight subjective symptoms, but proving a never-failing source for the transmission of the infection. A chronic urethritis in women may be suspected from the external reddening of the meatus, the eversion of the mucosa, the "flea-bitten" appearance of the orifice of Skene's tubules or the punctate reddening of the

tiny pits adjacent to the urethral orifice. If there is an ectropion of the mucosa the external openings of Skene's tubules may stand out prominently as dusky red spots. Occasionally peri-urethral abscesses may form in the vaginal septum.

Inflammation of Bartholin's Glands.—Because of their situation at the entrance to the vagina the ducts of Bartholin's glands are usually the seat of a chronic infection. Even if this is not present at first the initial attack is soon followed by involvement of this area. The persistent vaginal discharge bathes these orifices and the infection almost inevitably gains access to the ducts. Although infection of the urethra and vulva may run a fleeting or a self-limited course this rarely occurs in Bartholin's glands, for "once infected, always infected," is especially true of gonorrhea in this locality. Only by surgical extirpation of the gland can the infection be eliminated. Both glands are usually involved coincidentally, but occasionally the one gland becomes affected after the other. As the duct becomes occluded a cyst or a pseudo-abscess may form as the result of the accumulation of pus or the retention of the normal secretion within the gland. If a true abscess forms in this locality other abscesses will almost certainly follow, for the gland is not destroyed by the initial infection, only one or more acini being involved. Recurrent abscesses are the rule, as in turn one acinus after the other is involved, and the patient becomes a chronic sufferer from recurrent suppuration. When, finally, the gland is destroyed or extirpated abscesses cease to form.

In cases of chronic inflammation of this gland there is a small pigmented macule on the labial surface that surrounds the orifice of the duct; this spot, to which Sänger first called attention, is so constant as to be almost pathognomonic of a Neisserian infection. These darkened areas were formerly considered as positive evidence of the presence of a specific infection, and they may still be regarded as extremely significant evidence of gonorrheal infection. The deeper seated abscesses in Bartholin's glands are usually due to a mixed infection. A simple retention cyst may attain considerable size and be very painful, and, as a rule, complete extirpation is demanded to prevent its recurrence. Occasionally a deep incision into such a cyst and the application of tincture of iodine to the interior will effect a cure.

Cervicitis and Endocervicitis.—Although the secretions of the uterus and vagina are so prohibitive to the growth of ordinary pyogenic organisms, they appear to have no germicidal or even inhibiting effect on the growth of the gonococcus; it follows, therefore, that a gonococcal invasion of this part of the genital tract is usually tantamount to a chronic process that ultimately tends to ascend gradually until the Fallopian tubes are invaded. As in the urethra and vulva the initial attack is usually accompanied by a profuse purulent discharge, which soon becomes mucopurulent and then, finally, mucous. In this last stage the leucorrhea is free and persistent and is especially likely to be aggravated just before and after the menstrual periods,

due to the natural functional activity of the mucous glands at these times. In the acute stage gonococci are often abundant in the discharge, but later they may only occasionally be demonstrated. During the premenstrual and the postmenstrual days the bacteriological examination is most likely to show positive findings.

As a result of the persistent irritating discharge the cervix usually presents the same reddened appearance as the urethra. There is a zone of inflammation about the external os uteri; the glandular orifices may be occluded and small pustules, or more frequently, cystic follicles, are present. Within the cervix the infectious process may remain localized at a point just short of the internal os uteri, and may continue in this situation indefinitely without evincing subjective symptoms other than an abundant leucorrheal discharge. Such patients are usually ignorant of the true nature of this discharge and seek relief for what they believe to be merely a persistent leucorrhea.

Treatment.—When gonorrheal infection first appears in this locality a vigorous therapeutic policy should be pursued. The cervix should be exposed with a bivalve speculum and then cleansed of mucus with cotton pledgets. If the mucus is very tenacious a simple alkaline solution may be used to dislodge it. After the parts are clean, tincture of iodine or a strong solution of silver nitrate, or even formalin, should be applied to the cervix, with the aid of a cotton applicator. Particular care must be observed in applying formalin to the endometrium to avoid leaving any excess of fluid. Its corrosive action under these conditions is too intense and may lead to an actual sloughing of this tissue. If, as often happens, a cure cannot be effected by this means the use of the electric cautery, as suggested by Hunner, may be resorted to. This method consists of heating a thin-bladed electric cautery to a glowing redness and then making radiating incisions, starting at the external orifice and sinking sufficiently deep into the cervix to destroy the glands. This treatment may be carried out in the office at several sittings, but is usually more satisfactorily accomplished at one sitting under anesthesia in a hospital. A cervix treated by this method will, in a few days, present an angry ulcerated appearance, and it would seem, were one to pass judgment on the results at this time, that more harm than good had been accomplished. As the cautery wounds heal, however, a very different appearance is usually noted. The discharge diminishes, the cervical swelling subsides, and, as a rule, the cervix resumes a normal appearance. Enough glandular tissue remains to furnish a sufficient, but not an excessive, amount of mucus, and the leucorrhea may thus be effectively cured. If the infection has involved the endometrium of the fundus, failure will usually follow unless a coincident curettage is performed and the cavity of the fundus swabbed with a 5 per cent. iodine solution.

Gonorrhea of the cervix must be actively treated if a cure is to be effected. As applied to infection in this location we believe Noeggerath's dictum to be both erroneous and harmful. Active intervention may prove most effectual and may be the means of averting a chronic

ascending process. This is true, of course, only of those who have been innocently affected. The prostitute cannot be saved, for even if a cure is effected today a new attack may be contracted tomorrow. It is especially the young wife who will benefit most from this plan of treatment. It goes without saying that in the latter case the husband must also be treated actively and that sexual relations must be suspended until the presence of gonococci in both individuals can no longer be demonstrated.

Fundal Endometritis and Metritis.—There is no subject in gynecology in which the pathology and treatment have been so revolutionized as in endometritis. Up to the time of the publication of Hitchman's and Adler's epoch-making paper upon the cyclic changes that take place in the endometrium coincident with the flow and ebb tides of the circulation in its monthly preparation for the reception of an ovum the nomenclature of endometrial changes had no scientific basis, and a more or less haphazard policy was pursued in the classification of the various forms of endometritis. In their zeal the authors of gynecological text-books have often so far overshot the mark as to lead one to assume there was no tissue so frequently the seat of an inflammation and so often disorganized by bizarre pathological processes as the endometrium. As a matter of fact a chronic endometritis is of comparatively infrequent occurrence. We now know that progressive and retrogressive physiological changes take place in the endometrium, as, for example, the varying transformation of the exhausted and collapsed tubular endometrial glands immediately after the cessation of menstruation to the active hypertrophied and more or less irregular distended glands of the premenstrual epoch, this transformation merely marking the various phases of normal physiological activity. Formerly a specimen obtained by curettage was submitted to the pathologist, who based his report upon the microscopic findings, regardless of the period in the menstrual cycle during which the endometrium was removed. It is not strange, therefore, that a diagnosis of interstitial endometritis might be made as the result of an examination of the postmenstrual endometrium, because the glands were narrow and the stroma condensed, or the diagnosis be hypertrophic endometritis or even an adenomatous change bordering upon malignancy because the glands were hypertrophied and distended with mucus just antedating the menstrual period.

Now all this has been changed, and out of this pathological chaos comes order, for with the recognition of these varying changes the true pathological transformation may more accurately be judged, and hence the entire subject now rests on a very simple basis. In general it may be said that although a cervicitis usually becomes chronic and manifests but little inclination to undergo a spontaneous cure the corporeal endometrium displays a contrary tendency. So long as the process is an ascending one and has not reached the tubes a spontaneous cure may occur. If, on the other hand, the tubes are

invaded the constant seepage of infected fluids over the endometrium will set up a more or less chronic inflammation.

Reduced to its ultimate analysis endometritis may be classified in two divisions—acute and chronic. Of late much stress has been laid upon the necessity of finding plasma cells in the endometrium before a positive diagnosis of endometritis may be made. My associate, Dr. Charles C. Norris,[1] has investigated this subject carefully in our laboratory, and has reached the following conclusions, which are recorded in his splendid monograph:

"Glandular, and more particularly interstitial changes of sufficiently pronounced characteristics to warrant a diagnosis occur as the result of inflammation, and while it has nearly always been possible to demonstrate the plasma cell in both acute and chronic cases, which makes it of great diagnostic value, I do not consider its presence essential for the diagnosis of endometritis." In Norris's opinion, therefore, the diagnosis should not rest entirely upon this finding. He discards such terms as glandular, interstitial, and polypoid endometritis, a decision with which I am in the fullest accord.

The inflammatory reaction to the gonococcus which takes place in the endometrium is in no sense specific and cannot be distinguished from that induced by any other pyogenic irritant. It is only by the demonstration of the Diplococcus Neisseri that the diagnosis can be positively made. In acute cases this is easily accomplished, in chronic endometritis the findings are usually negative. In acute endometritis the surface of the mucosa may present areas of granulation, whereas in other cases there may be epithelial proliferation. The glands vary in size, some being of normal dimensions, whereas others may show considerable enlargement or even cystic changes. Inflammatory conditions in the stroma may give them a compact or even an atrophied appearance. As a rule the epithelium shows a marked inflammatory reaction. The stroma is edematous and infiltrated with polymorphonuclear leukocytes, and frequently contains free blood. The myometrium underlying the endometrium is usually infiltrated with the products of acute inflammation.

In chronic endometritis this deeper infiltration subsides and the most marked pathological changes are observed in the superficial endometrium. The surface epithelium is flattened and may be desquamated in one area and hypertrophied in another. At times even a metaplasia from a columnar to a squamous type may be observed. As the result of occlusion the glands may be enlarged and cystic, and, owing to the changes that take place in the stroma, an irregular arrangement of the glands, with bay-like projections, may occur. The gland may contain serum, leukocytes, blood or epithelial débris. The stroma is more or less infiltrated with inflammatory products. When the endometrium is of the chronic type, the myometrium may become more or less involved. In the acute stage the uterus is slightly

[1] Gonorrhea in Women, 1913.

enlarged, whereas in cases of long standing it may undergo a fibrosis and actually shrink in size.

Treatment.—A positive opinion concerning the treatment of endometritis cannot be expressed unequivocally, for as yet a consensus of opinion as to the best therapeutic course to pursue has not been reached. Acute cases, as a rule, do best without interference, for Nature will usually deal more kindly with this disease than will the physician. Meddlesome therapeutics, especially those of a topical character, are hazardous in the extreme—no benefit is to be derived from such treatment and great harm may result. As has previously been stated an acute corporeal endometritis may terminate spontaneously, and it is far better to await this result than to attempt to facilitate cure by local measures. It is much easier to spread the infection to the tubes than it is to cure the acute process. A difficult point to determine is just when the acute process has ended and the chronic condition sets in. In this determination the symptoms do not aid us, but, in a general way, it may be said that when the chief symptom, a persistent profuse leucorrhea, has continued unremittingly for six months a chronic stage has been reached.

What is our attitude toward the curette? It is our opinion that no instrument in the gynecologist's armamentarium has been so much misused as this one. There is no doubt but that, used, as it was, indiscriminately in the past, it brought in its train infinitely more of harm than of benefit. Every operator has had the unpleasant experience of performing a curettage in a case of chronic endometritis in which a profuse leucorrhea was the chief symptom of the inflammatory process, with immediate relief, only to be followed by a prompt recurrence. For a time, to the patient's great relief, the distressing discharge ceases and all evidences of an endometritis are abruptly terminated. Within a few weeks or months, however, the patient usually returns with all her old symptoms, and in some cases these are even exaggerated in degree. What has happened to cause this recurrence? In several instances in which the uterus was removed because of a general pelvic inflammatory involvement the writer has vigorously curetted the organ after its removal, having no regard as to the infliction of traumatism, which latter is so assiduously avoided when curettage is performed in the ordinary way for diagnostic or therapeutic purposes. He has then had serial sections made of the uterus from the cervix to the fundus. This simple experiment revealed the cause of failure to eradicate the disease. The curette does not reach the tubal angles in the uterine cornua, where infection always is hidden. With the regeneration of a new endometrium all goes well for a time and then a descending infection from these hidden angles takes place and there is a gradual increase of the leucorrhea until its former volume is reached. A simple curettage, therefore, may temporarily improve, but it does not cure, an endometritis. As a chemical aid to a cure we invariably make a liberal application of iodine to the curetted mucous membrane. This may

be most effective in reaching the deeper areas of the disrupted membrane, and with its germicidal action the infectious process may be terminated.

Acute Salpingitis.—Very seldom, indeed, does an acute infection of the tubes take place coincident with, or even immediately after, the initial urethral or cervical infection. More often an interval of weeks or even years elapses between the original infection and the acute tubal inflammation, the intervening period being marked by acute exacerbations of cervicitis and endometritis. Symptomatically the transition of the inflammatory process from the uterus to the tubes is very evident. The usual mild subjective distress in cases of endometritis is present, together with varying degrees of leucorrhea and menstrual pain of more or less intensity. Fever and constitutional symptoms are usually absent. As the tubes are invaded, however, the clinical picture undergoes an immediate change. There is severe pain in the lower abdomen, being more marked, as a rule, on one side than on the other, or it may be entirely localized on one side. If this happens to be the right side the symptoms may so closely resemble those of appendicitis as to make the diagnosis almost or quite impossible.

Although the initial symptoms may be very stormy, indicating that a severe pathological change is taking place in the tubes, under appropriate treatment they may quickly subside and never return. This happy termination, however, is so rare as to be noteworthy, since sooner or later recurrent attacks will almost inevitably take place. In the interval between attacks the patient may pursue her normal activities, being quite free from disabling symptoms, and in many instances there will be no pain or discomfort until another attack occurs.

In these acute cases the usual pathological changes of inflammation take place, there are swelling and edema of the tube and the fimbriæ become congested and bluish red in color. The enveloping peritoneum is thickened and a profuse purulent exudate may exude from the tube. If the attack subsides promptly there may be very little pathological residue, but, unfortunately, this termination is not usual, as more often decreasing constitutional symptoms mark its transition to the chronic stage. Changes now occur that more or less permanently disable or distort the tube. The peritoneum becomes thickened, there is a considerable increase in the connective tissue of the muscular wall and the delicate mucous membrane is seriously disturbed. First, a large part of the ciliated epithelium is destroyed and the branching coral-like folds of the mucosa become agglutinated and then fused, forming small, loculated areas of pus. If this chronic inflammation persists localized nodulations may form along the course of the tube (salpingitis nodosa).

During the transition from the acute to the chronic stage the round-celled infiltration and plasma cells, together with the associated vascular hyperemia, gradually give place to new connective tissue of

a relatively poor vascularization. In the acute stage gonococci may be found in great abundance, but in the later stage they disappear. When the ampullary end of the tube is closed by the infolding of the fimbriæ through a purse-string-like constriction of the peritoneum, which contracts until all the fimbriæ are concealed within the lumen and the tube becomes completely sealed. This closure is usually accompanied by so sharp a kinking or narrowing of the isthmal portion of the tube as completely to obstruct it at the uterine end and thus a true pyosalpinx is formed. The tube now becomes distended and may increase in size to the large sausage-shaped mass, the ampular ends, owing to their increasing weight, dropping into Douglas's cul-de-sac. The resultant inflammation in the surrounding peritoneum gives rise of the formation of adhesions and the ovaries become embedded in a mass of exudate that is organized into more or less dense connective tissue.

Because of the monthly ebb-and-flood tide in the pelvic circulation the patient suffers with recurring attacks of pain in the ovarian regions, which are especially severe during the premenstrual and menstrual days and subside during the interval between the periods. Acute exacerbations also occur during the menstrual periods, and if conception is still possible a very severe attack may be precipitated by a miscarriage or a full-term parturition. Although the patient is able to be about she is never really well, and sooner or later, unless a radical operation is performed, develops into a chronic invalid. The changes in the pelvic connective tissue may be so extensive that complete freedom from pain is not achieved even through surgical intervention. In the latter case the pathological changes are too extensive to permit a perfect cure to be effected. Because of the dense adhesions that form with the surrounding intestines, and especially with the sigmoid flexure or rectum, a mixed infection may occur and as the result of the passage of colon bacilli into the infected area a large pelvic abscess is formed, in which colon bacilli are found in great numbers.

Gonorrheal Inflammation of the Ovary and Pelvic Peritoneum.—The discharge of pus from the open fimbriated extremity of the Fallopian tube or from the rupture of the tube may give rise to a pelvic peritonitis. In rare instances a generalized peritonitis may be produced, but this is so rare as scarcely to warrant consideration here. This well-established clinical fact simplifies the differential diagnosis between a generalized peritonitis and the early stages of an inflammatory attack, due to appendicular involvement.

In gonorrheal infection only the generative organs and the immediately surrounding pelvic peritoneal surfaces are involved. The exciting factor may be looked upon as of a chemical origin, being the toxic products of the gonococcus rather than the actual organism itself. Unquestionably gonorrheal pus teeming with Neisserian organisms reach the general peritoneal cavity, but the bacteria are quickly neutralized and rendered innocuous by the peritoneal fluid.

During this stage of neutralization the clinical picture may closely resemble that of a general peritonitis caused by a more dangerous pyogenic organism. The differentiation is made by putting the patient to bed in the Fowler position and applying ice-bags or the ice-coil to the abdomen; in the case of gonorrhea of the tubes the symptoms of general peritonitis, if they are present, quickly subside and the pelvic nature of the attack becomes apparent.

Adhesions between the tube and the ovary may cause fusion of these organs and sooner or later a tuboövarian abscess of a considerable size may form. Occasionally an ovary that is quite free from adhesion with the tube may become the seat of an abscess. In the latter condition we are forced to regard this as a hematogenous infection, but since these infections are so rare there is still a suspicion that the exciting factor has gained access to the ovary through the temporary opening in a follicle or a corpus luteum. In long-neglected cases the purulent process may burrow into the perirectal tissues and into the parametrium. Sooner or later a rupture may take place into the vagina, rectum or even into the bladder, and very rarely into the peritoneal cavity.

The Expectant and the Surgical Treatment of Gonorrheal Infection of the Adnexa.—In recent years the tendency of the majority of the leading gynecologists has been to regard the cure of gonorrhea of the internal generative organs as practically hopeless, and as a result they have viewed with great skepticism any statements bearing on a possible cure of the disease. Because of this therapeutic nihilism a radical operative policy has held active sway until the last few years. There then began to emanate simultaneously from various clinics of the continent, and, more slowly, from those in America, suggestions as to the wisdom of adopting a more conservative policy. It was found that upon putting patients to bed and following a palliative plan of treatment the acute symptoms soon subsided, and long before there was any appreciable diminution in the size of the tubes these patients had frequently become so comfortable that they refused or accepted with great reluctance, any advice looking toward surgical intervention. If rest in bed were further persisted in along with appropriate symptomatic treatment the mass often disappeared completely, the slight rise in temperature dropped to normal and the patient was discharged from the hospital wholly relieved and quite free from subjective symptoms.

As the reports of cases so treated began to multiply and were followed by the publication of serial reports in which this plan was successfully followed a general conservative policy became the rule, so that now, when a surgeon brings an acute case before his colleagues for operation he places himself at once on the defensive, and to save himself from adverse criticism his plea must be that the symptoms have been so acute as to be seriously confusing, and he has, therefore, failed to differentiate between a tubal infection and an appendicitis.

What then is the course of the disease in these conservative cases?

Unquestionably the occasional case in which the subjective symptoms, have disappeared may never have a recurrence of symptoms, and, to all intents and purposes, may fully recover. The majority of cases, however, do not terminate so fortunately. Some patients are quite comfortable between the menstrual periods, but most of them display symptoms varying from a slight discomfort to severe pelvic pain during the premenstrual and menstrual days; others again have recurring attacks even between periods, and these render them semi-invalids. Sterility is the lot of almost every woman who has suffered from a double salpingitis, and in considering surgical action in these cases the question of future fecundity as an influencing factor in determining the best mode of surgical treatment may be ignored.

It is not therefore the child-bearing possibilities that should dominate a decision in favor of a conservative policy, but, rather, the preservation of the ovarian function. When a patient suffering from an acute salpingitis or a pyosalpingitis is admitted to the hospital she should at once be placed in bed in the semiprone posture. If the inflammatory process is in the ascendant, ice-bags, or, what is usually more soothing, the Leiter coil, having a continuous circuit from an ice-water reservoir, is applied over the lower abdomen and kept constantly in contact with this region until the pain begins to subside. Copious hot douches of at least a gallon of boiled water, at a temperature of 110° to 115°, are given slowly twice daily. The value of this treatment rests solely on the application of heat to the vaginal fornix, and, therefore, if it is to be effective the water must be retained within the vagina sufficiently long to permit an ample radiation of heat. This may be accomplished most effectively by elevating the hips upon a douche-pan, so that the vaginal vault is well filled. The influx must be so regulated that at least twenty minutes will be consumed in giving the treatment. Since there is little possibility of spreading an infection through the peritoneal cavity as the result of active peristalsis, the bowels should be moved daily. Such active purgatives as cause griping, as, for example, calomel or blue mass, should not be given in these cases. A liberal dose of castor oil should be administered at the beginning of the attack after the differential diagnosis has been made to thoroughly clear the bowel. This may subsequently be followed by a simple laxative. An excellent routine daily evacuate consists of liquid paraffin, to which may be added from 10 to 30 minims of fluidextract of cascara if the intestines do not respond promptly to paraffin alone.

The restriction of diet is dependent solely upon the patient's digestive powers. In the great majority of our cases, after the first few days, during which they are kept upon a restricted liquid diet, with an abundant ingestion of water, the patients are placed upon a regular but a limited dietary so far as acids, rich sauces, condiments and alcoholic beverages are concerned. As a result, usually the first twenty-four to thirty-six hours of treatment show a gratifying

improvement in the acute symptoms. It may be remarked here that during the stage of nausea or vomiting the granting of a normal or even of a soft diet is quite obviously out of place. The restrictive plan of Ochsner should always be followed until the differential diagnosis between a tubal infection and an appendicitis or a peritonitis of some other origin can be made. If nausea is persistent, and particularly if there is epigastric distention, gastric lavage should be practised every four to six hours and the drop method of enteroclysis should be utilized. As soon, however, as the stomach becomes retentive and the normal intestinal peristalsis is restored, fluids should again be given by the mouth, for the average patient objects to the prolonged practice of enteroclysis. There is apparently no method of treatment used more ill-advisedly than this one of enteroclysis. Why the colon, instead of the mouth, if the stomach is retentive, should be utilized as the source of aqueous intake is inexplicable, and yet many physicians and surgeons appear to think that the absorption of a saline solution by the bowel possesses a particular or magic virtue.

While the diet is limited to liquids a capital food, and one of easy digestion, is dairy buttermilk. Of this at least a quart a day should be given. Urotropin, in doses of 10 grains thrice daily, should be prescribed. The patient must be kept in bed until the diurnal fluctuation of temperature reaches normal and remains there. Simpson, who has had remarkable success in the treatment of these cases, and though his splendid observations has rightly earned the position of the first American pioneer in placing this plan of treatment upon a a permanent basis, insists upon an absolute subsidence of temperature, one that is not disturbed by a bimanual pelvic examination. If, following this manipulation, there is even a slight rise above the normal, he regards this as a positive contra-indication to operation, for he believes that this symptom indicates that an active process is still at work, and an operation at this stage may open up cellular infiltrates that will hazard the result of the operation or even imperil the life of the patient. He attributes his splendid surgical results, than which there are no better, to this ultraconservative policy. In our own practice we have found that this method kept our hospital beds occupied indefinitely, and, being unable to give over the hospital days necessary to this treatment, we have adopted a modification of Simpson's policy. Thus we are guided by the temperature drop to normal, with at most a 0.5° rise, and the palpable disappearance of appreciable masses and relaxation of adjacent rigid tissue. Under this plan our mortality has been reduced to its lowest percentage. Healing of wounds is infinitely better, pelvic peritonitis is very infrequent, the stormy convalescence of former years is no longer a menace and a breeder of surgical anxieties, and when the patient is discharged from the hospital there is little in the way of pelvic masses, such as were formerly the usual sequela when the operation was performed during the stage of acute infiltration.

As a rule, when a patient enters the hospital with her first attack of acute salpingitis she is kept in bed until all pain has subsided and the temperature has dropped to the normal. She is then permitted to get out of bed and walk about the ward. If her symptoms recur or her temperature rises a degree she is again put to bed, to remain there until the ambulatory ward test, when repeated, is not followed by a rise of temperature. She is then examined, and if masses are still palpable an operation is advised. If, however, the pelvis is quite free from infiltration she is permitted to return to her home, but is warned of the danger of a recurrence and of the necessity of a prompt return to the hospital if this takes place. Instructions are given regarding the diet and the regulation of the bowels. If an offensive or free leucorrheal discharge appears, as is most likely, a simple douche for cleansing purposes is prescribed. We have found the following combination useful:

℞—Acid boric . . . . . ℥vj
Alum exsic. . . . . ℥j
Phenol . . . . . ℥j
Ol. gaultheria . . . . . f℥j
Ol. menth. pip. . . . . f℥ss
M. et ft. pulv.
Sig.—Two drams in one quart of hot water once or twice daily.

On returning home the patient may thenceforth remain quite well or a recurrence may take place within a short time. The patient should always be warned of the possibility of this recurrence, and it should be explained that while we hope for a permanent cure we can by no means be certain of securing it. If this is not clearly impressed on the patient her disappointment may subject the physician to censure and she may seek relief elsewhere.

As a result of this treatment a certain percentage of cases can be spared any operative procedure whatever. Prochownick, between 1892 and 1905, by the expectant method, treated and then reëxamined 160 patients, and claims to have cured 55 per cent. His method consists of rest in bed, applications of ice, followed after a time by moist heat and later by exposure to hot air, the use of the mercury colpeurynter for two to three hours daily and the insertion of a hard-rubber cylinder in the vagina at night. This investigator also believes more than one-half of the chronic inflammatory affections of the adnexa can be cured permanently by this method. Henkel states that in 80 to 90 per cent. of all inflammatory cases "subjective healing" occurs following judicious non-operative treatment. Olshausen is a firm believer in palliative treatment, and in his clinics, operations for pyosalpinx are, if possible, deferred until nine months after the occurrence of the infection and when the temperature has again reached the normal. Under the palliative treatment the infective microörganisms in many cases become innocuous and the uterus and adnexa to a certain extent return to the normal. Nature has thus been allowed to cure as much of the disease as possible, and when

the abdomen is opened the best mode of operation for the individual case can be more easily decided upon. There is no doubt that by adopting the expectant treatment a greater number of cases will be found suitable for conservative operations than if they are at once subjected to operation. Moreover the mortality will be reduced. Simpson has recently reported the results of 475 consecutive abdominal sections for inflammatory lesions of tubal origin, with only 4 deaths. In addition to the reduced mortality the postoperative results will be improved. It will be found that the operations can be performed with greater speed, that a shorter period of anesthesia will be required, that a fewer number of herniæ will follow and that a lessened proportion of infections and consequent postoperative adhesions will be encountered. By converting acute inflammatory infections of pelvic origin into aseptic lesions the mortality will be reduced and the postoperative results improved. Occasionally cases will be encountered that will not improve under this waiting treatment, but the more carefully these cases are observed the fewer will be the number requiring immediate operative intervention. Sänger, a pathologist and gynecologist *par excellence*, was the first to lay stress on the fact that chronic adherent appendages were not the seat of infection but were merely the derelicts of the gonococcal storm. The cases in which operation should not be delayed, or at least for any length of time, are those in which an abscess can easily be evacuated without entering the abdominal cavity. Accuracy of diagnosis is the necessary adjunct to this treatment, and only by its aid can the surgeon successfully adopt the waiting policy.

When a patient returns or is admitted with a history of repeated attacks we follow the same policy of treatment upon her admission to the hospital, and as soon as the symptoms subside an immediate operation is advised as the only method by which permanent relief from the attacks can be secured. If surgical intervention is delayed, structures that might still have been conserved may be destroyed utterly, as the result of subsequent attacks that will almost invariably follow.

Vaginal Incision.—If when the patient is first seen she has been suffering for some time from a chronic gonorrheal pelvic infection that has developed into a large pyosalpinx or a pelvic abscess, or if, under conservative treatment, this issue is reached the proper treatment is prompt evacuation of the pus through a vaginal incision. In such cases nitrous oxide anesthesia is to be preferred to ether, although the latter may be used if the former is not at hand. This operation is almost free from danger so far as immediate surgical mortality is concerned, and the patient, freed from the large collection of septic matter, quickly improves and may entirely recover. Of course the pelvic anatomy is so seriously disorganized that the tubes almost never become patulous again and the ovaries are usually invested in a more or less dense mass of adhesions. Notwithstanding these extensive pathological changes it is a singularly noteworthy

fact that in a considerable proportion of cases the patients are relieved from disabling symptoms and are capable of carrying on their usual vocations. In our experience 65 per cent. never require a secondary operation. In the remaining 35 per cent. a radical operation is sooner or later required for the removal of the uterus, ovaries and tubes. As the uterus is surrounded by adhesions it is especially likely in the stage of subsidence to be drawn backward and to become more or less densely adherent to the rectum.

The great advantage of a vaginal incision is that in the larger majority of cases it effects a cure and in the smaller percentage of cases that later require a celiotomy this operation is rendered much safer. The keynote of surgical success in pelvic inflammatory cases is unquestionably never to operate during the acute infection if this can be avoided. If, however, the operation is demanded the less done the better. To evacuate the pus through a vaginal incision and wait until the acute inflammatory process has subsided and all exudate has been removed by Nature, while it may possibly be regarded as a temporizing measure, is surely to be commended, for in this way the mortality incident to the surgery of acute inflammatory conditions will be reduced to almost a negative percentage.

When the patient reaches the stage of abscess formation she is, as a rule, weak, anemic and physically much below normal. Her resistive powers are greatly reduced and hence she is in no condition to undergo an extensive abdominal operation. In former days, when these cases were invariably subjected to abdominal section, the mortality was never less than 8 per cent., and often reached a higher mark. In capable hands, governed by the surgical indications that obtain at present, the mortality in all inflammatory cases subjected to abdominal section falls below 2 per cent. A prominent factor in reducing the immediate mortality in cases of vaginal drainage is the short time consumed by the operation. The fact that the peritoneal cavity is not invaded and the small amount of anesthesia required also play an important rôle in the reduction of mortality.

As nearly all these abscesses may be incised under nitrous oxide anesthesia, even the slight disadvantage of etherization may be obviated. The chief argument in favor of this procedure is the fact that it is unquestionably a life-saving measure, devoid of the much greater risks that attend a celiotomy. Even if, in the end, it is not curative, it will render safer a more radical abdominal operation after the patient had recovered from her septic condition and only the residium of her inflammatory attack is to be disposed of. The mortality from vaginal incision and drainage is less than 1 per cent. Contrasted, therefore, with a more radical operation through an abdominal incision, the advantage, so far as grave hazards are concerned, is all in favor of the evacuation of pus by the vaginal method of treatment.

Certain precautions are absolutely essential for success by this measure: First, the abscess must be pointing in the vaginal fornix

or so close to it that it can be reached without danger of puncturing the intervening intestine. Occasionally the ileum is caught in the abscess and may lie between the purulent collection and the vaginal wall. By careful bimanual palpation this fact can usually be ascertained. If in doubt an abdominal incision should first be made and the exact topography of the abscess outlined.

Occasionally an assistant may greatly facilitate the vaginal operation by pressing down upon the abscess through the abdominal incision, thus bringing it within closer range in the vagina. In some instances we have carefully packed off the abdominal cavity, aspirated the pus sac and then opened it, establishing through-and-through drainage from the abdominal incision to the vagina. This method is most advantageous in those cases in which the abscess is located in one quadrant of the pelvis. In such cases the abdominal incision is sutured closely around the drainage tube, which is of the Mikulicz wick variety. The vaginal end of the wick and tube are gradually withdrawn after six days, a small portion being cut off each day. By the tenth day it is all out, and, as a rule, the cavity is so far healed that the patient may be permitted to sit up. If there is fever the patient is kept in bed until the infectious process has become quiescent. The patient is then gotten out of bed, for we believe that convalescence is facilitated in this way. Formerly we made it a routine procedure to employ a douche, even going so far as to wash out the abscess cavity with a two-way irrigator; this practice has now been abandoned, (1) because it does not facilitate the healing, and, (2) by rupturing the sac and flooding the peritoneal cavity, may prove very dangerous, and be attended with fatal results. There should be no haste to remove the drain. It must never be removed in less than five days, and usually we do not remove the gauze entirely until the tenth day. The cavity is never repacked. At most if there is retention of pus the vaginal fistula is dilated, thus permitting complete drainage until the cavity is quite healed. These patients may usually be discharged by the fourteenth day. Special instructions are given for their guidance, and they are impressed with the necessity of returning to the hospital or coming to the surgeon's office from time to time until they are either well or, as will be the case in one-third of those thus treated, until the time arrives when they may be sent back to the hospital for more radical measures.

CONSERVATIVE SURGERY OF THE FALLOPIAN TUBES, THE OVARIES AND THE UTERUS.

The Fallopian Tubes.—In a paper published in conjunction with Dr. Norris,[1] in 1910, the authors gave the end-results of a series of 191 cases in which conservative surgery of the pelvic organs had been carried out in the gynecological department of the University Hospi-

[1] Conservative Surgery of the Pelvic Organs, Surg., Gynec. and Obst., 1910.

tal, Philadelphia, together with a careful analysis of these cases. As a very potent fact, it was demonstrated that little of permanent value can be obtained by attempting to conserve the Fallopian tubes. Small adherent tubes, in which the abdominal ostia are closed, should be excised. The only condition in which a salpingostomy is ever justifiable is in old, non-active hydrosalpinges. One of the chief anatomical defects of a simple salpingostomy is that, in a great number of cases, the intramural portion of the tube, as well as the abdominal ostium, is occluded. The usual after-history in all forms of salpingostomy is that the newly formed ostia close up and a recurrence of symptoms takes place, and this despite the utmost care in the performance of the operation. The percentage of cases in which pregnancy takes place after salpingostomy is small, whereas recurrences are frequent. Small or normal-sized tubes, in which the abdominal ostium is open, may be freed from adhesions, but better results will usually be obtained by the extirpation of such organs. Unless there is some special indication making maternity desirable it is the writer's belief that a conservative operation on the tubes should not be performed. When such an operation is necessary the patient should be advised as to the nature of her condition and warned as to the likelihood of failure, and she should be the one to decide the type of operation to be performed

The general unsatisfactory results obtained by conservative tubal surgery may be attributed to the fact that in the great majority of cases salpingitis is of gonococcal origin. The gonococcus is persistent, and once having established itself in a location suitable for its growth it is practically ineradicable unless the affected area is so situated that it is easily accessible to local treatment. This persistence of the infection is responsible for many of the failures that follow conservative surgery.

The brighter side of conservative tubal surgery is presented when we consider those cases in which the tube on one side is normal, whereas the other is diseased. In these cases the normal tube should be disturbed as little as possible. Excellent results have been obtained by this treatment, and comparatively few such cases require a second operation.

When a salpingectomy has been decided on the radical operation, *i. e.*, the removal of a wedge-shaped portion of the uterine cornua, together with the intramural part of the tube, should be the operation of choice. The writer has seen several cases of cornual abscess and one case of intramural tubal pregnancy taking place in the stump left by a previous salpingectomy, when the intramural portion of the tube had not been excised.

Conservative Ovarian Surgery.—The ovary is the analogue of the testicle in the male, and its physiological potentialities is quite as important. In order, therefore, to preserve the organ, considerable risks are justifiable. When diseased tubes are excised the only effect on the patient is that she is rendered sterile, a process that has usually

been previously performed by the pathological process. When, however, a double oöphorectomy is performed in women under thirty years of age the operation may convert a previously normal woman into a hopeless neurasthenic. The sudden onset of the artificial menopause, with its accompanying nervous symptoms, the inability successfully to fulfil the marital relations, together with the mental effect produced by the cessation of the menses, the knowledge that is more or less suddenly and forcibly brought to the woman's mind that she is prematurely aged, and that the possibilities of maternity have forever been removed—all these tend to produce a most pitiable condition. There is no doubt but that the age at which a double oöphorectomy is performed, together with the individual temperament of the patient, plays a very decided part in the after-history of these cases. It is also true that some women bear the results of the operation better than do others. Too much importance, however, cannot be placed on the age, as Peterson has shown that some of the most serious effects of the artificial menopause occur when the ovaries are removed between the ages of forty and forty-four years. Although some patients may experience little discomfort as the result of the operation, more than half of those operated on will suffer very seriously, and occasionally the result will be little short of appalling. One has only to follow the after-histories of a few cases to be convinced of the disastrous effects of a double oöphorectomy. In a large series of cases in which both ovaries were removed, Giles found that in most cases the flushes and other symptoms of the artificial menopause continued for from three to four years, and in some individuals persisted for ten years.

He also found that severe mental depression occurred in from 10 per cent. to 33 per cent. of cases, and of 157 cases 2 became insane. Sex instinct was entirely abolished in 16 per cent. of cases and diminished in a further 16 per cent., it being only a matter of time when this was entirely lost. The assertion has been made that if one ovary is allowed to remain this is sufficient. This is on the principle that "half a loaf is better than no bread." Patients upon whom a unilateral oöphorectomy has been performed often menstruate scantily and have an early menopause. Giles, after a careful review of 1000 abdominal sections, of which 50 were unilateral salpingo-oöphorectomies for pelvic inflammatory disease, concludes that the removal of one ovary causes irregularities, diminution or cessation of the menstrual flow in a definite proportion of cases (16 per cent. of his) and that in a somewhat smaller proportion (12 per cent.) the sexual desire is lessened or entirely abolished. In 133 cases that came under the writer's care in which one ovary had been removed, menstruation was diminished or irregular in 50. Carmichael in animal experimentation found that when one ovary was excised there was a compensatory hypertrophy of the other, and this doubtless takes place to a certain extent in the human race. This may also account for some of the irregular bleedings that are occasionally observed following conservative surgery.

A further comparison between the tube and the ovary shows that the essential structure of the tube, *i. e.*, the mucosa, is chiefly involved, whereas in the ovary, at least in gonococcal infections, the important portions of the organ are destroyed only in the last stages of the disease. A peri-oöphoritis is the most frequent accompaniment of pyosalpinx and only in the advanced cases is an actual oöphoritis present. For this reason, when the primary source of the infection is removed, the ovary is prone to undergo resolution. The histological examination of 368 ovaries removed consecutively for pelvic inflammatory disease at the University Hospital, Philadelphia, showed 253 cases of perioöphoritis, thus testifying to the relative frequency of this condition.

In some cases resection of an ovary is attended by favorable results. The presence of pus in an ovary is, however, an indication for its complete removal. Esch regards the pus contained in ovarian abscesses as being of a peculiarly virulent character. Many such cases are undoubtedly of puerperal origin, the pyogenic microörganisms having traveled directly through the broad ligament to the ovary. Notwithstanding this, in carefully selected cases ovarian resection may be performed with fairly good results. If it has been found necessary to remove the ovary on the opposite side, or when the abscess is a small one and is so situated that it can readily be excised, and even if only a small amount of ovarian tissue can be left behind, the sudden onset of the menopause is often averted. In general, however, it may be stated that resection of an ovary possesses a very limited field of usefulness, the proportion of these cases that require a secondary operation being much higher than when an entire ovary is conserved. This is due to two factors: In the first place a resected ovary is always a diseased organ or more or less disorganized, and, in the second place, apart from the necessary mutilation, the circulation is often impaired by the ovarian sutures. These must be passed deeply into the substance of the ovary, and as this organ receives its blood supply from a central circulation the latter is always more or less disturbed. Polak, in his careful study of the after-histories of these cases, finds that all resected ovaries become much more enlarged after the operation. In the favorable cases this enlargement begins to subside in about four weeks. Turretta has studied the after-results in a large series of ovarian resections and regards the operation as indicated in selected cases; he believes that the reparative power of the ovary is very great. Christiana states that the cut surfaces of a resected ovary heal by a process of connective-tissue formation and that the cicatrix is gradually pushed to the surface. In two ovaries upon which resection had been performed, and which were examined histologically by my associate, Dr. Charles C. Norris, serial sections were made of the removed organs and no confirmatory evidence was obtained that new ovarian tissue is produced to take the place of the resected portion. Both of these specimens were of normal size. In one the scar could be distinguished

microscopically, whereas in the other it was not visible to the naked eye but could be detected with the aid of a microscope as a thin line of avascular connective tissue on the surface. That compensatory hypertrophy does take place seems to be certain, but this is a very different process from regeneration. This belief is founded on the study of the author's own cases and is borne out further by the work of Carmichael and Bell.

The cases that are most favorable for resection are those in which a single retention cyst exists, and this is especially true if the cyst tends to become pedunculated. These single retention cysts should not be confused with cystic degeneration of the ovaries. The latter do not promise good results from any form of conservative surgery. Boldt, in performing oöphorcystectomy, endeavors to save a portion of the ovary and has had only one bad result in 45 cases. The necessity of leaving the ovary with an unimpaired blood supply cannot be overestimated, and if this is found to be impossible an oöphorectomy should be performed. Ovaries that are allowed to remain after a hysterectomy or after ablation of the corresponding tube have been found to cause subsequent trouble, often undergoing polycystic degeneration, becoming enlarged and tender and sometimes prolapsing into Douglas's cul-de-sac, or, if this does not occur, they may become adherent and painful. While this is occasionally the case the author is of the opinion, however, that the cause of these untoward results lies not so much in the ovary as in the method of performing the salpingectomy.

The important facts to be considered in performing a conservative ovarian operation are the maintenance of a proper blood supply and the securing of an ovary in a good position, preferably in its normal location in the ovarian fossa. If these desiderata are secured the cystic degeneration of the ovary, the dyspareunia and other distressing sequelæ can be averted. This opinion is further strengthened by a review of the after-histories of cases of engrafted ovaries, which latter almost invariably become cystic. Souve, in his recent exhaustive study of ovarian transplantation, finds that in almost all cases cystic degeneration supervenes, a condition, he believes, that is due to an imperfect blood supply.

In addition to what has been said, special attention must also be paid to covering all raw areas, so that adjacent organs may not become adherent, and, the formation of postoperative adhesions, cause as much discomfort as did the original condition. All rough handling and trauma of the ovary should be avoided during the operation. In those cases in which a resection has been performed, special care should be taken accurately to coaptate the cut surfaces of the ovary, guarding against constriction of the tissue. The sutures should be so passed that no dead space will intervene. Absolute hemostasis should be secured. Martin lays great stress—and very properly—on the necessity of controlling all bleeding points in cases of pelvic inflammatory disease. There is no better culture medium

than are blood clots. In conserving ovaries, as in all other branches of surgery, the ability to make the pathological diagnosis while the diseased organ is *in situ* is of the utmost importance, and for this reason surgeons should accustom themselves to study carefully all removed tissue.

It is quite important to observe that the uterus, as well as the ovary, be left in good position. If attention is not paid to this detail the uterus may, by traction on the broad ligament, produce a disturbance in the ovarian circulation or actually draw the ovary into a painful position.

Conservative Uterine Surgery.—With our increased knowledge of the function of the ovaries, and with the cognizance that without these adnexa the uterus is a useless organ and that a better support to the roof of the vagina may be obtained by performing a supravaginal hysterectomy, nearly all operators are agreed on the advisability of performing a hysterectomy whenever a double oöphorectomy is required. Reed has recently pointed out that in these cases if the uterus is allowed to remain it may be the cause of much pain. Giles found that in 62 cases in which a bilateral salpingo-oöphorectomy was performed the uterus subsequently gave trouble in 7 and 2 required a second operation. This observer has prepared the following table, showing the atrophic results occurring after bilateral salpingo-oöphorectomy:

	Under 2 years. Per cent.	Under 5 years. Per cent.	Over 5 years. Per cent.	Total number of cases.
Uterus and vagina normal . . .	38	26.7	18	17
Uterus or vagina atrophied . . .	31	33.0	54	20
Uterus and vagina atrophied . . .	31	40.0	27	18

These findings constitute a further argument in favor of removal of the uterus when it is found necessary to perform a double oöphorectomy.

Carmichael and Marshall found that when the ovaries of young animals were removed the uterus underwent a fibrous degeneration.

Not infrequently a case is seen in which the question arises: Shall a hysterectomy and a bilateral salpingo-oöphorectomy be performed and certainly cure the patient of her present trouble or would it be advisable to perform one of the conservative operations? To decide this question many factors should be taken into consideration, as, for example, the age of the patient, whether she has a number of children or is particularly desirous of maternity, whether she has to gain a livelihood by hard manual labor, what is her social status, and, lastly, but of almost paramount importance, the temperament of the individual patient. Even after a careful study of each case has been made and all points bearing on it have been reviewed it will still be difficult, in not a few cases, to decide what is best for the ultimate welfare of the patient.

Based upon a decennial division of a woman's life after twenty years we follow a conservative principle almost invariably up to

her third decade. We unhesitatingly take the risk of a recurrence of the inflammatory lesion rather than to perform an unsexing operation. The loss of the child-bearing function is insignificant compared with the abrogation of sexual characteristics. It is the latter which brings so much of physical and psychic disability to the younger individual.

In the decade beyond thirty years the problem is not so difficult of solution because of the nearer approach to the climacterium. In this decade the sexual function is not so likely to be disturbed, especially if a sexual habit has been established during the preceding years. The inauguration of the procreative impulse or libido sexualis is dominated largely by the subsidiary centers of the spinal cord. After the sexual life has been established and fixed habits are formed the psychic centers chiefly dominate this instinct. We find, therefore, that instead of abrogating this function by the removal of the ovaries it may actually be restored if the lack of sexual desire or dyspareunia has been caused by pelvic inflammatory disease. In the resumption of sexual relations after such an operation the psychic influence has full play, and in the absence of pain a complete sexual climax may occur. In young nulliparous women there may be such a shrinkage of the vagina, from atrophy of the muscular tissues, as actually to cause an absolute bar to sexual intercourse. In such instances the future of the patient may indeed be a wretched one and all too often a divorce court sooner or later terminates a very unhappy marital existence.

The surgeon who looks upon the human body as a mere machine and ignores the enormous forces encompassed within the sphere of the emotions, the mainsprings of happiness, will certainly have to his discredit in the summary of results many cases which will date their unhappiness and wretchedness to an unsexing operation. Successful, yes, in actually removing or stamping out the disease, but unsuccessful in that it leaves in its train an unhappy individual, a prey to morbid introspection and dominated by disordered nerves or a pathological psychology. In my experience it is indeed rare to find a young woman between eighteen and thirty years of age from whom the ovaries have been removed who is ever again restored to a normal physical and psychic existence.

Hysterectomy.—The median abdominal incision is usually the one of choice, and it is immaterial whether it is made along the line of the linea alba or through muscular tissue. We have not found the Pfannenstiel incision applicable to these cases, (1) because it does not give adequate room for the best manual manipulation of the pelvic structures, and (2) it does not permit a satisfactory investigation of the abdominal organs. The frequency of postoperative ventral herniæ does not depend upon the line of incision, provided a good approximation and healing of the aponeurotic coverings of the muscles is promoted.

Before incising the peritoneum the most painstaking hemostasis is

essential, and while this may be a bit more time-consuming, ample reward is noted in the perfection of the primary union. Ever so slight a collection of blood in a wound invites infection. It is wise, therefore, to ligate even the smaller capillaries before the peritoneum is incised. Formerly we depended upon the pressure of the hemostats or torsion of the vessel to take care of the smaller vessels, but this had not proved entirely satisfactory. Next in order is the careful protection of the wound by linen or gauze napkins to prevent even slight contamination and to lessen traumatism and to shield the peritoneal surfaces from even slight staining with iodin. A 5 per cent. solution of iodine is a capital disinfectant for the skin surfaces, but it carries with it the disadvantage of producing adhesions unless it is excluded from the peritoneal cavity. After the protecting napkins are applied an inventory of the pathological conditions is made. If the gastro-intestinal symptoms point to a possible coincident involvement of the gall-bladder, stomach or appendix the decision to investigate these organs rests upon whether the pelvic inflammatory lesion is quiescent. Under the latter condition a cyclic examination of the other abdominal organs may be made, but never if there are still evidences of an active pelvic infection.

This examination should always be made before the pelvic organs are manipulated. The wound at this stage is aseptic, the gloved hand is uncontaminated and no septic matter has been liberated in the pelvis. A complete summary of possible pathological conditions is thus obtained and each may be dealt with according to its importance. In our opinion one of the best points in Crile's excellent technic is his insistence upon gentleness of manipulation of peritoneal surfaces. The pride which surgeons formerly felt in working through a small incision now gives way before the better results coming from a larger incision. Through an ample opening, and by this we mean one if necessary extending from the symphysis to or above the umbilicus the peritoneal manipulation may proportionally be limited. In the earlier stage of anesthesia, if the patient is still resistant and the abdominal walls are stiff and rigid, patience becomes a virtue in waiting for a more complete relaxation before attempting to wall off the field with gauze. The intestines should be gently pushed up and out of the pelvis and retained with moist gauze. When this step is satisfactorily completed the adherent structures are released, if not too dense. In the latter event one of the alternative methods of hysterectomy may be chosen.

Hasty or rough separation of adhesions is a surgical error of no small magnitude. Usually digital separation of adhesions is easily accomplished, if not either a sharp knife or curved scissors must be utilized. After the pelvic structures are liberated the extent of the ovarian involvement is ascertained, for a satisfactory conservation depends upon the surgeon's judgment at this point. Ovaries, which are extensively cystic or are involved with more or less dense adhesions, or an organ which has been disrupted in breaking it away

from its cleavage points, do not lend themselves kindly to a conservative operation. These organs must be measurably healthy and intact if they are to be left *in situ*. In the presence of pus it is an error to leave them. If the ovaries are to be removed a suture or, if preferred, a thin-bladed hemostatic forceps is applied just outside of the outer pole of the ovary; if a conservative operation is chosen then to the uterine sides. In the event of the removal of the uterus and the conservation of the ovary the tube is detached, the excision being made just beneath the tube. Every effort should be made to prevent traumatism to the veins. Even a capillary travelling thrombus in the parovarian tissue may so involve the ovarian plexus as to cause vascular disturbances sufficient to vitiate the ultimate result of the conservative attempt. Usually before this step is taken the round ligaments are doubly ligated and detached from the uterine cornua. These ligaments subsequently are to be used as suspensory bands for the cervical stump. Next the uterine vessels are similarly treated. At this point it is the custom of the majority of surgeons to detach the vesical fold of peritoneum from the uterus and by blunt dissection to push off the bladder from its cervical attachment. The objection to this procedure is that the connective tissue beneath the trigonum is broken up and disturbance in the middle and inferior vesical circulations are created. Under these conditions, in the event of a slight extravasation of blood or infection about the cervical stump, it may easily push its way beneath the trigonum and cause great vesical disturbance, which may run from an acute course into a state of chronic inflammation, thus leaving, as a sequel to an otherwise successful operation, a vesical disability which may be greater than the one for which the operation was performed. This danger may largely be obviated in a very simple way. Instead of detaching the vesical reflection below its fixed point on the anterior wall the uterus is incised just above it. A deep wedged portion of the cervix is removed from the cervix. After the supravaginal portion of the uterus is removed, leaving only the cervical stump, two methods are available for the destruction of the cervical mucosa and the immediately underlying myometrium. Either a Paquelin point or, still better, a large, heavy platinum loop of an electric cautery is thrust down into the cervical canal and allowed to remain for a few moments at red heat. The mucous membrane and the underlying muscular tissue are thus destroyed, effectually sterilizing this area and ensuring the patient against a future carcinomatous involvement of the cervix. If a cautery is not available the cervix should be cored out with a sharp knife or short scissors curved on the flat.

It is not necessary to remove *in toto* the cervix, for quite as much may be accomplished in this easier way, and with less risk to the patient, than if a panhysterectomy is performed. After this step is completed the round ligaments are brought down and in turn are securely sutured into the stump, thus assuming the function of suspensory ligaments for the cervix. With this method there is rarely

if ever a prolapsus of the portio vaginalis. When this step is completed it is found that there is little to do in the way of enveloping the stump with peritoneum, as a fine running catgut suture will expeditiously do this and a very neat closure is effected. It is important to avoid dragging the stump high in the pelvis and fixing it with the ligaments under strong tension. This will lead to a sense of pulling and discomfort when the patient gets on her feet, which may last for some weeks or even longer and make the patient very anxious and unhappy for fear that further trouble is impending.

We only resort to panhysterectomy when there is a large hypertrophied or deeply lacerated cervix with erosion. The total removal of the uterus is slightly more hazardous. In preserving the cervical stump the vaginal vault is maintained and the patient's comfort will be enhanced. Arguments advanced in favor of the total removal of the cervix centers about the danger of leaving a focal point of infection. This objection may be overcome by the use of the cautery or the excision of a cervical core. A further argument in favor of a panhysterectomy is the possible danger of carcinomatous invasion of the stump. Again we meet the objection by the statement that in but one instance in our experience has this occurred, and even then, it was a continuance of a carcinoma of the fundus associated with a myoma uteri which had been overlooked. When the patient returned for the second operation the specimen previously removed was again studied and the error detected. Summarized briefly we lay special stress upon the following points in a hysterectomy:

1. Complete hemostasis even to the ligation of capillary vessels. In this way postoperative deposits in the broad ligaments and cellular spaces are avoided, giving a quick and satisfactory convalescence.

2. The separate detachment and ligation of the round ligaments, which are subsequently utilized as suspensory bands for the cervical stump.

3. The amputation of the cervix above the vesico-uterine peritoneal reflection without the detachment of the latter. This detail largely obviates chronic vesical irritability and precludes the possibility of a subtrigonal hematoma or an infection.

Drainage is very seldom employed and practically never through the abdominal incision. Occasionally an opening posterior to the cervix into the vagina is made, through which a small gauze wick is inserted. This gives adequate drainage and leaves very slight after-effects. Only when there is considerable oozing or when adherent pyogenic tissue remains is drainage employed. In waiting until the acute symptoms have subsided and the pelvic exudate largely absorbed, drainage of the pelvis will be relegated to the historical epoch in the evolution of the treatment of pelvic inflammatory conditions by hysterectomy.

Hemisection of the Uterus.—When the uterus is densely adherent and the lateral structures are bound up in a cystic mass or closely fused with the surrounding peritoneum, as is so likely to be the sequel of a

bad or long-standing pelvic peritonitis, it may be extremely difficult to reach the ovarian or uterine bloodvessels without great traumatism and the hazards of profuse hemorrhage. Also in breaking up these dense masses by lateral approach and undermining there is the danger of injury to the ureters, sigmoid flexure and rectum or bladder. Under such conditions it will be found much easier and safer to utilize the method suggested by Kelly and Faure. The two horns of the uterus are caught in stout, grasping forceps and pulled as high as possible into the wound. With a sharp scalpel the uterus is split from above downward in the midline. When the cervico-fundal juncture is reached one-half of the uterus is then undercut laterally. By firmly pulling upward on this half a sufficient gap is made through which a curved hemostatic forceps is inserted to catch the uterine artery. The remainder of the dissection is then comparatively easy, the inflammatory mass being turned out until the ovarian vessels are reached, when they are clamped and one-half of the uterus and corresponding appendages are removed. The opposite half may then in a similar manner be even more readily extirpated. From this point on the operation proceeds in a similar way as the simple hysterectomy.

Hysterectomy Beginning at the Cervico-fundal Juncture.—In cases of acutely retroflexed uteri densely adherent to the rectum the best method is that suggested by Kelly. If the fundus of the bladder is adherent to the uterus, as is usual in these cases, it is gently dissected loose either with a sharp knife or curved scissors. When the cervico-fundal juncture is reached, stout grasping forceps are applied and the uterus is cut through until the posterior wall is passed. Through this opening a finger is inserted and the adhesions between the rectum and uterus are loosened by digital dissection. Thus liberated the uterus is pulled up and through the gap the uterine arteries are clamped. By continuing the dissection upward and backward the fundus may be liberated and the ovarian arteries ligated. This plan is very seldom of service, but in the occasional case it is of the greatest value and converts an otherwise extremely hazardous operation into one of comparative ease.

PYOGENIC INFECTION OF THE PELVIC ORGANS OTHER THAN GONOCOCCAL.

There are many varieties of bacteria capable, under exceptional circumstances, of producing septic infection of the genital tract, but in the large majority of cases the causative factor in these serious pelvic inflammatory conditions is the streptococcus. As a rule this microörganism is the sole genetic cause, but occasionally other organisms are present as well, the commonest of these being the colon bacillus. Although there are several varieties of streptococci, fortunately many of these are apparently non-virulent or incapable

of producing a serious infection. The species that appears to be endowed with the most potential virulence is the streptococcus longus seu erysipelatis. This organism not only exerts a most destructive effect on local tissue but possesses a rapidly fatal hemolytic action as well.

Besides the streptococcus there is also a subordinate group of coccal and rod-like bacteria that may induce a purulent inflammation. Of these the staphylococcus aureus and staphylococcus albus and the bacillus coli are the more common, the pneumococcus and the bacillus aërogenes capsulatus possessing rarer genetic influence. Although we speak of a bacterial toxemia as distinct from an infection, this differentiation is often more a theoretical than a practical one. It is impossible to determine the critical point in the progress of an infection—that is, the time when the absorption of toxic products ceases and the invading organism begins to penetrate the deeper tissues or gains access to the blood and lymph currents. Theoretically, sapremia could be induced by the action of the yeast-producing fungi, Saccharomyces, from the innocuous air bacteria, but such theories may be very misleading, so far as their clinical application is concerned. Too often the physician deludes himself with a diagnosis of sapremia, whereas in reality a grave septic infection may be in progress, just as he may, in a similar case, prescribe huge doses of quinine to overcome a malarial attack. To enter here on a lengthy dissertation on the manifold activities and characteristics of the countless varieties of microörganisms would only create confusion. Apart from the gonococcus the organism possessing the greatest clinical importance, and most frequently encountered in the serious infectious inflammations of the pelvic organs, is the streptococcus, and for this reason only this organism and the pathological disturbances produced by it will be considered here.

The incidence of infection occurs chiefly during the puerperal process, and more frequently in the course of abortions and miscarriages than during the normal parturient process. Fortunately the vaginal secretion possesses a defensive action that protects women from the dangers of pyogenic infection, for, be it remembered, no premature birth and but seldom one that is considered normal occurs in which some trauma is not inflicted on the parts, thus offering an atrium for infection were it not for this germicidal property of the genital secretions.

In addition to the accidents incident to the puerperal state, streptococcic infection may occur as the result of careless use of uterine sounds, the unskilful introduction of stem pessaries, the removal of small polypi or even following manual examination of a patient without proper antiseptic precautions. It is to the criminal abortionist, however, that a large majority of these infections may be traced, and this is true particularly in our larger cities, where this evil flourishes.

Sooner or later in the practice of every physician is he likely to

encounter a fatal case of streptococcus infection, due to the use of an unclean vaginal syringe.

Although the interior of the normal non-pregnant uterus is sterile, after childbirth or miscarriage the open cervix may be the seat of streptococci. A patulous internal os, which is wedged open by a polyp or a submucous myoma, is also likely to harbor streptococci that remain latent until a traumatism occurs, when a septic infection is set up and a tragic sequel is the result. Every surgeon has observed in his practice a swift exitus after what appeared to be a very satisfactory and simple hysterectomy. Indeed, these operations are so free from apparent hazard that often no thought of danger enters the mind of the operator until the alarming rise in temperature and rapidity of the pulse, with the quickly supervening lethal symptoms, warn him of approaching danger. In such cases streptococci will be found in the cervical canal, and, with the excision of the uterus, the microörganisms become disseminated, entering the parametrium and the peritoneum and causing the fatal termination. As has previously been stated, it is impossible to draw an accurate dividing line between a so-called bacterial toxemia and an infection; a relatively satisfactory clinical differentiation may, nevertheless, be made, and this is most important from the standpoint of treatment.

Bacterial Toxemia.—The presence in the genital tract, and more especially within the uterus, of degenerating structures, such as the remains of decidual, chorionic or placental tissue, necrotic polypi or foreign substances, such as gauze packs that may have been overlooked following operative procedures, may if allowed to remain for any length of time, set up a toxemia the result of decomposition. The ordinary air-bacteria that produce fermentation, *e. g.*, Bacillus aërogenes, are present practically always, and even in the absence of pathogenic organisms a toxic product is elaborated that, if absorbed, will give rise to a definite systemic reaction, characterized by a slight rise in temperature, headache, backache and possibly chilly sensations or an actual chill; beyond these manifestations no serious symptoms are noted. With free drainage of the genital tract no systemic reaction will, as a rule, occur, even if the uterus contains a foul, decomposing mass.

When such decomposing substances are removed or discharged all the symptoms at once begin to abate, and within a few hours have subsided completely and the patient is quite normal again. Considerable discussion has taken place during the last five years concerning the propriety of undertaking immediate surgical measures in these cases. The customary practice in the past has been to free the uterus at once of any degenerating material, in the belief that the patient was thus protected from serious harm. A newer school, however, insists that Nature is better able to care for these cases and that meddlesome interference is only productive of harm. In the obstetric literature of Europe, and to a lesser extent in that of America, several very interesting discussions on this subject are recorded.

Recently, one of the German clinics has reported the most remarkable results following this touch-me-not policy. On the heels of this an advocate of the policy of prompt removal of degenerating substances offered a brief that was equally, if not entirely, convincing. Here, as in all other branches of medicine where opposite tenets are held by two groups of controversialists, each showing excellent results from the employment of divergent plans of therapeutics, the safest plan to follow is a "middle-of-the-road" policy.

When a miscarriage has occurred and the cervix is tightly contracted, with retention of chorionic or placental remains, emptying of the uterus by instrumental means is not justifiable unless hemorrhage threatens or there is a rapidly rising temperature. In these cases it has too often been the custom of the average physician, as well as of the surgeon or obstetrician, forcibly to dilate and often to curette the uterus, with resulting trauma. Such a policy is occasionally tragically hazardous, and cannot be decried too severely, for Nature's method of dealing with such cases is infinitely more kindly.

As a working rule, action may safely be delayed until the cervix has become well dilated. Not infrequently a week or ten days may elapse before the offending mass is expelled spontaneously or the cervix is sufficiently dilated to permit of removal of the substance without curettage. It is the abrasion of the uterine wall attending instrumental removal that may give rise to the direct consequences, and for this reason the gloved finger should be used when detaching any adherent bits of placental débris. When the cervix is not sufficiently dilated to admit the index finger a dull curette may be used gently to detach the foreign mass. If the placental tissue is so firmly adherent as to require forcible avulsion the safer method is merely to dilate the cervix and to pack the uterus with iodized or weakly iodoformized gauze until Nature effects the detachment.

The germicidal action of the vaginal secretion will combat a septic infection with greater certainty and with less hazard than attend the use of antiseptic douches. If the application of an antiseptic is indicated, iodine in 2 per cent. solution, applied either with a uterine syringe or by means of a cotton applicator, will be found more satisfactory than the antiseptic douches. In the event of malodorous discharge, irrigation of the vaginal tract under very light pressure, say one foot elevation of the douche bag, with the patient in the sitting posture, is sufficient for cleansing purposes. If no odor is present the douche is best dispensed with, mere cleansing of the external genitalia being sufficient.

Summarizing, in a general way, one may set down the following rules as working postulates:

1. In the absence of fever or of hemorrhage of threatening degree the expulsion of retained chorionic or placental tissue may safely be left to Nature.

2. A contracted os uteri accompanied by a rising temperature indicates dilatation of the cervix. If the tissue is detached it should

be removed. If it is adherent and bleeds easily it is safer to pack the uterus with gauze wrung out of a 5 per cent. iodine solution and wait for spontaneous expulsion or further detachment to take place.

3. The use of powerful intra-uterine antiseptic douches is strongly to be deprecated; at most only a simple cleansing vaginal douche, given under very low pressure, is permissible.

4. Of all practices the employment of a sharp curette is most reprehensible. Occasionally a dull curette may be used to dislodge a bit of foreign tissue, but even this should only very rarely be resorted to.

Septic Endometritis and Metritis.—In septic endometritis the bacterial invader usually excites the initial inflammatory reaction at the point of attached or degenerating decidual tissue or in an abraded or a lacerated cervix. The necrosis produced by the action of the streptococcus often results in the formation of a grayish-white diphtherial membrane. Beneath this membrane an active inflammatory reaction takes place, together with a frontier zone of round-celled infiltration and leukocytic invasion. If no further bacterial invasion into the myometrium occurs the grayish membrane is soon exfoliated and replaced by healthy granulation tissue, and thus the endometrium is gradually restored.

Symptoms.—The severity of the symptoms is dependent upon the virulence of the microörganisms, the strength of the local barriers and the resistance of the patient. As in all other parts of the body the clinical manifestations may be mild and evanescent, consisting of a rise in temperature to 100° or 101° F., with an accompanying pulse-rate of 90 to 110, slight pain on pressure over the uterus and disturbance of the patient's general condition, which is marked by backache, headache and the like. In such cases a few days see a return to the normal. The bacterial evidence of infection, so far as the uterine secretion is concerned, disappears and the secretions become sterile, and, like a fleeting pharyngitis, the attack is over. If the bacteria penetrate to the myometrium the course of the disease is slower and more pronounced, so far as the symptoms are concerned and the condition is always serious. The temperature, which at first may have shown an acute rise, with associated acceleration of pulse, now becomes lower but steadily persistent, and then assumes the morning fall and evening rise so characteristically depicted by what is known as the "steeple" temperature chart.

In such cases the discharge may be absent, or slight and non-odorous, this being in sharp contrast to those cases in which there is retained placental tissue. In acute virulent infection of the endometrium or myometrium death may occur in a very few hours through the entrance of the microörganisms into the blood stream. In these cases the patient is overwhelmed by the intensity of the infection and succumbs before any radical local inflammatory reaction has taken place. All efforts to check such a fulminating infection are unavailing.

Diagnosis.—In the ordinary case the diagnosis can, as a rule, be made without difficulty. Pain is not marked but the patient com-

plains of general symptoms, such as backache, headache and the like, which are induced by the fever. On inspecting the cervix the grayish membrane may be seen and a bacterial study of the lochia in the earlier stages usually reveals the presence of infectious microörganisms. If the symptoms are urgent a blood culture should be made, for upon the result of this investigation rests the prognosis. A positive culture is always ground for grave anxiety, for, as a rule, the outlook is unfavorable. When microörganisms are free in the blood stream the patient almost invariably dies. The pelvic examination is negative. The uterus may be slightly hypersensitive to touch, but board-like rigidity in the vaginal fornices is absent. For a simple examination a dull curette may be utilized. The instrument is passed lightly into the uterus, where it encounters smooth walls, and there is no débris. In these cases the treatment is non-surgical. To curette such a uterus, to use strong antiseptic intra-uterine douches or to interfere manually in any way is positively to be interdicted.

Treatment.—The after-care of the patient is entirely medical. The semiprone posture should be maintained and large, flaxseed poultices, made up with a 1 to 2000 mercury bichloride solution, should be applied continuously, over the lower abdomen, and a diet modified to suit the digestive condition, with supporting remedies; these constitute the sheet anchor in the treatment. Not infrequently one finds, when called in consultation, that the patient is laboring under quinine intoxication, large doses of the drug having been given in the belief that great good could be accomplished, when, in reality, the opposite is the case. Small doses of quinine may be beneficial, exciting, as they do, a leukocytosis, whereas larger quantities inhibit this process. Not more than 15 grains a day is permissible, and even this amount may prove harmful if continued over several days.

In general the patient, as I have observed these cases, is better without quinine. After all the case runs its course, terminating either in a satisfactory resolution or in the death of the patient. The dangers of blood infection are always great, and even when the patient takes a turn for the better a fatal meningitis, pleurisy or pneumonia may supervene. From the very beginning of the infection until recovery is completely established the outcome is problematic.

Not many years ago hysterectomy was recommended as a routine procedure in all these cases, but within recent times there has been a return to the conservative treatment as just outlined. It is exceptional, nowadays, to find a representative surgeon who advocates removal of the uterus in these cases. By such operative measures he interferes with the inhibiting action of nature, and, by opening up the parametrium or invading the peritoneal cavity, he thus invites disaster. Briefly summarized it may be said that in such cases hysterectomy is rarely if ever indicated.

Parametritis and Pelvic Abscess.—A septic endometritis or metritis if it passes beyond the walls of the uterus in its route of dissemination, travels through the lymph channels of the parametrium. The

lymph nodes and lymph glands of the broad ligament constitute the first barrier to progress, and at these points an acute inflammation occurs. Whereas in an endometritis or a metritis there may be slight or no uterine hyperesthesia, in a parametritis, on the other hand, the pain is usually quite severe. The greater the induration and the consequent pressure upon the pelvic nerves and the more severe the tension on the peritoneum the more intense does this symptom becomes. In these cases the infection may become rapidly disseminated and the patient quickly succumbs. Fortunately, however, the progress of the infection is arrested more frequently in the broad ligament, and although the course may be a prolonged one, extending over days or weeks, under appropriate treatment the patient usually recovers. So far as impending death is concerned the anxious days of parametrial infection are the early ones, during which the temperature is high and the pulse rapid. As soon as the temperature declines and assumes an irregular course, with an evening rise and a morning remission, the process, as a rule, is becoming localized and can more easily be managed, so far as local treatment or surgical intervention is concerned. It generally spreads backward and laterally along the utero-sacral ligaments, and in this way considerable perirectal exudate may be formed.

More rarely the inflammatory process may surround the cervix beneath the trigonum, and thus the broad ligament of the opposite side may become invaded. The loose cervico-vesical connective-tissue attachment permits this invasion to take place, whereas the fixation of the peritoneum on the posterior aspect of the cervix acts as an effectual bar to extension of the infection to the opposite side. An infection, therefore, that becomes localized in the anterior parts of the broad ligament may extend across to the opposite broad ligament, whereas if it extends posteriorly, as a perirectal inflammation, this rarely if ever occurs.

Symptoms.—In the early acute stage of parametritis the broad ligament becomes tense and edematous, and as the tissues are subjected to greater tension, pain naturally increases. The next stage may be one of resolution, with gradual shrinkage of the distorted tissues, and after several days or weeks a complete *restitutio ad integrum* takes place. This is the striking difference between a chronic gonococcal and a streptococcal infection. The former condition seldom if ever kills, but the tissues that have become extensively involved practically never return to the normal. The streptococcus, on the other hand, strikes with greater violence and very frequently kills, but should the streptococcal infection subside the tissues may again become essentially normal. A few writers have reported isolated cases of streptococcic infection that have remained latent for months or even years, and then the organism becoming liberated, as the result of some operative measure, a fulminating infection and death ensue. This danger is, however, a very slight one and may practically be disregarded when considering frequent or constant

factors. The gonococcus persists but the streptococcus dies. The streptococcus is a suicidal organism, for if confined within a limited space it is almost invariably destroyed by its own toxins. For this reason in a pelvic abscess of two or three weeks' duration a positive culture is seldom obtainable. In this way, also, the rapid recovery of these patients after spontaneous rupture of the abscess into the vagina or even into the rectum is explained.

If the parametritis undergoes resolution before abscess formation actually takes place, recovery is usually complete. If, on the other hand, an abscess develops this happy termination seldom ensues, although the resultant scar tissue may cause little or no discomfort. In other cases the pressure caused by the perineural connective tissue is sufficient to give rise to severe nerve pain, which is referred down the anterior and posterior aspects of the thighs. Furthermore, in rare instances sufficient pressure may be exercised upon the pelvic veins to cause varicosities or edema of the legs. Such sequelæ as these are difficult to treat satisfactorily, massage, exercise and patience, on the part of the patient, constituting the factors necessary to effect an amelioration of the symptoms.

When the pelvic infiltration goes on to abscess formation the areas of fluctuation may be outlined in well-marked anatomical boundaries. Thus a parametrial abscess distends the base of the broad ligament and the strong, resistant fascia which forms the covering of the levator ani muscle tends to deflect the purulent accumulation toward the vaginal fornix or rectum. On examination, therefore, the point of fluctuation may readily be detected in one or the other vaginal fornix, or if the purulent exudate has been shifted posteriorly it may be palpated through the rectum. The subtrigonal space anterior to the cervix may be infiltrated and of board-like hardness, but only seldom does an abscess point in this locality. It usually extends laterally into either of the broad ligaments, even if this space were the original point of infection. Such an abscess seldom points in the anterior vaginal wall.

When a parametrial infection has ended in suppuration, through the shrinking of scar tissue, the uterus, ovaries and tubes may be drawn into very distorted positions, causing such extreme disability as later to make surgical intervention for relief necessary. Seldom are the tubes or ovaries in a parametritis directly infected by contiguity of structure. They may, however, become adherent, and thus a hydrosalpinx or a tuboövarian cyst may form; or, as more frequently happens, these organs may return to the normal without any of these sequelæ supervening. When the broad ligament is honey-combed with small abscesses prolonged suppuration may ensue. In these cases one large abscess either opens spontaneously or is emptied by the surgeon, and then, for a time, slight amelioration of symptoms occurs; in other cases, again, no perceptible improvement is noted. In such instances abscess after abscess may form, the patient being worn to a shadow as the result of her suffering and

septic condition, until death ends the scene. With proper supervision, however, this obstinate course may be overcome and the patient then makes a slow and tedious recovery.

As has previously been stated the symptoms in parametritis or pelvic cellulitis, are usually ushered in with a chill and an acute rise in temperature, followed quickly by an acceleration of the pulse-rate. A pulse-rate below 110 is a good harbinger, but one that rises steadily to 140, 150 or 160 is of grave significance. So long as the temperature remains high, 104° to 105° F., and the rapid pulse persists, the danger is great; a declining pulse-rate, however, even if the temperature remains high, offers a much more favorable outlook. A rapid pulse-rate with moderate temperature must be viewed with far greater apprehension than when the temperature is high and the pulse-rate below 100.

During the initial five to ten days of the infection the chart may show a persistent elevation of temperature and tachycardia. The patient may have recurring chills—an alarming symptom always—or there may be only slightly chilly sensations. Headache, constipation and backache, with pain in the long bones, is a common grouping of symptoms during this acute epoch. The sharp, pelvic pain, the tympanites, with nausea and vomiting, and the constipation may so closely simulate peritonitis in the earlier stage as to make a differentiation impossible. The most helpful diagnostic signs are board-like rigidity and extreme tenderness in one or both vaginal fornices. In the earlier stage it is difficult or impossible to determine whether the infection is a peritoneal, tubal or parametrial one.

Treatment.—When surgeons thought it necessary to make a sharp differentiation between the various forms of pyogenic infection in order to outline the appropriate treatment the symptomatic and diagnostic aspects of the case gave rise to serious concern. Now, however, so to speak, all roads lead to Rome so far as treatment is concerned. Ochsner has pointed the way to the non-operative treatment of peritonitis. Simpson and others have shown the fallacy of immediate operative intervention in salpingitis and pyosalpinx and other well-known observers have warned against the greater danger of hasty surgery in parametritis as against a conservative course of treatment. Thus we find ourselves, when on the horns of a dilemma, turning with great assurance to the non-operative methods, since statistics now amply sustain this course in the earlier treatment of the case. After a few days the symptoms usually become sufficiently clear to establish the diagnosis.

In ovarian thrombophlebitis, which is so serious a complication in these cases, the surgical treatment has also been discarded. The value of the plan suggested by Trendelenburg, which consists of ligating or excising the spermatic or ovarian veins in these cases, has not been sustained by clinical experience, and is unworthy of further trial. In such cases as these the symptoms, as a rule, progress from bad to worse, the patient falling into a profoundly septic state, which usually terminates in death.

In passing a word must be spoken as to the use of antistreptococcic sera. Nothing was more alluring than the hopes originally engendered by this form of serum therapy. The method bore all the scientific ear-marks, such as a positive culture, the determination and separation in pure culture of the organism and the preparation of an antagonistic serum. Assuredly this was a happy outlook? Nevertheless, experience, which proves all things, has never been able to dispel the doubts as to its efficacy. Indeed, in the majority of cases antistreptococcic serum is used only as a last resort. Occasionally an apparently marvelous cure may be reported, but these cases are so rare that one may pause in making his inventory of results, for equally good results have apparently followed from the use of some other agent. In general, one may say, therefore, that, although there is no serious objection to the conservative use of this serum its indiscriminate employment is harmful. In one case coming under our observation a man of moderate means, in addition to losing his wife, together with the necessary expenses thus entailed, received a bill of over one hundred dollars for antistreptococcic serum.

If a serum is administered and no impress is evident after from three to five days its use should be discontinued, for it is valueless and may prove actually harmful. As these cases progress and pus accumulates in the cul-de-sac if the condition is a peritonitis or a pyosalpinx, or an abscess points in the vaginal fornix or a suppurative parametritis is present, the time for surgical intervention is at hand. In operating the vaginal route should almost invariably be chosen. The procedure is a simple one, since it is not necessary to invade the peritoneal cavity, the resulting shock is slight, particularly if nitrous oxide is the anesthetic employed and the subsequent drainage is excellent. The mortality incident to this operation is almost negligible, and 65 per cent. of cases require no subsequent operative measures. In the remaining 35 per cent. an abdominal section is necessary sooner or later, usually for the relief of distress incident to the formation of adhesions or to malposition of the uterus, ovaries and tubes. When the operation has been performed, however, the infection is relieved and we have to deal with the aseptic residuum of the inflammatory process, which has now assumed the smallest proportions. The great advantage of this method of treatment is that, in young women, it offers a strong probability, at the secondary operation, of conserving a functionating part of the ovaries or even of restoring to fecundity an otherwise sterile woman.

Peritonitis.—The symptoms and treatment of peritonitis have been referred to in the earlier part of this book. Other chapters will deal exclusively with this condition. Suffice it to say here that the general plan of treatment suggested by Ochsner is that adhered to. In the writer's practice an operation is never performed in cases of puerperal infection until a collection of pus has become localized in the pelvis. An incision preferably is made through the vagina under local or nitrous oxide anesthesia, drainage is instituted and the Fowler position is rigidily maintained.

CARCINOMA, MALIGNANT CHORIONEPITHELIOMA AND SARCOMA OF THE UTERUS.

By HENRY SCHMITZ, A.M., M.D., F.A.C.S.

CARCINOMA UTERI.

The epithelial cell new growths of the uterus, with very few exceptions, are malignant. Carcinoma of this organ is more frequent than of any other human organ, excepting the stomach of the male. Next to myomata of the uterus, it is the most frequent of the uterine tumors. It has been stated that 3 per cent. of gynecological diseases are cancers (Chrobak) and that one-third of all women suffering from cancer have uterine carcinoma. Women of the poorer classes have carcinoma more frequently than myomata, while the reverse is true of the well-to-do. Myoma occurs mostly in the corpus, carcinoma in the cervix. Multipara have carcinoma more frequently, while nullipara have myomata more frequently.

We do not know anything about the direct etiology of cancer, but it is generally acknowledged that pathological epithelial proliferations form the origin of carcinomata. It has not as yet been determined what stimulates these cells to malignant growth.

Cancer usually occurs in middle life, 35 per cent. during the fifth, 25 per cent. during the fourth, and 24 per cent. during the sixth decade. However, no age is exempt. The average duration of life of a woman having a cancer of the uterus if left to itself is about two years. Soft medullary carcinomata grow more rapidly than hard scirrhus cancers. Cancers occurring in the young, or accompanied by pregnancy, tend to an earlier fatal termination, probably due to the much greater blood supply and the soft juicy character of all tissues during these states. The direct causes of death are: Cachexia and general cancer disease, 17 per cent.; inflammatory disease of lungs, 15 per cent.; peritonitis, 10 per cent.; severe complications of bladder, as cystitis, pyelitis and uremia, 51 per cent. (Simmonds).

The symptoms, course and prognosis of cancerous uteri differ depending on the location of the tumor, whether it originated in the cervix or in the corpus. Whatever marked differences exist between the two will be mentioned subsequently. From 8 to 11 per cent. of carcinomata uteri occur in the corpus. Corpus cancers occur oftener in the nullipara than in the multipara. About 50 per cent. of corpus carcinomata occur in the sixth decade, about 20 per cent. in the fifth and about 17 per cent. in the seventh.

Pathology.—The types of epithelial cells of the cervix differ, the vaginal surface being formed of squamous epithelium, and the endo-

cervix surface as well as glands is covered with cylindrical cel
Malignant proliferation of these cells should lead to the formation
either squamous or cylindrical epithelial-cell carcinomata. Howeve
the latter cancer is rarely seen, for the cylindrical-cell epithelium
almost invariably changed by a metaplasia into squamous-ce
epithelium.

The cancer cells are arranged in columns which penetrate into t
underlying tissues in every direction. They may coalesce and simula
a network of bands of carcinoma tissue, in the meshes of which son

FIG. 149.—Section from tissue of portio vaginalis, removed March 3, 1914. Mrs. M., St. Mary's Hospital, No. 23957. Ocular 10, eyepiece 16 mm., tube length 160 mm. A squamous-cell cancer with large masses of finger-like projections into the parenchyma of the cervix. *A*, an advancing column of malignant cells; *C* and *D*, islands of keratinized cells (epithelial pearls); *B*, an infiltration of small round lymphocytes surrounding the carcinoma columns. The whole picture is that of an actively advancing cancer of an atypical new growth of cells probably arising at the junction of the vaginal and cervical portions of the mucosa. (Author's preparation.)

normal tissue is retained. The less the amount of connective-tissue framework left between them, the larger and thicker the columns grow. Epithelial cancroidal pearls due to cornification are not frequent. They may, however, occur. But it is much more usual that the epithelial cells in the center of the columns soften and degenerate. Their places are taken by leukocytes and remnants of epithelial cells as nuclei without cellbody. Adenocarcinomata may originate from the epithelium of the cervical glands but are very rare (see Figs. 149, 150 and 151).

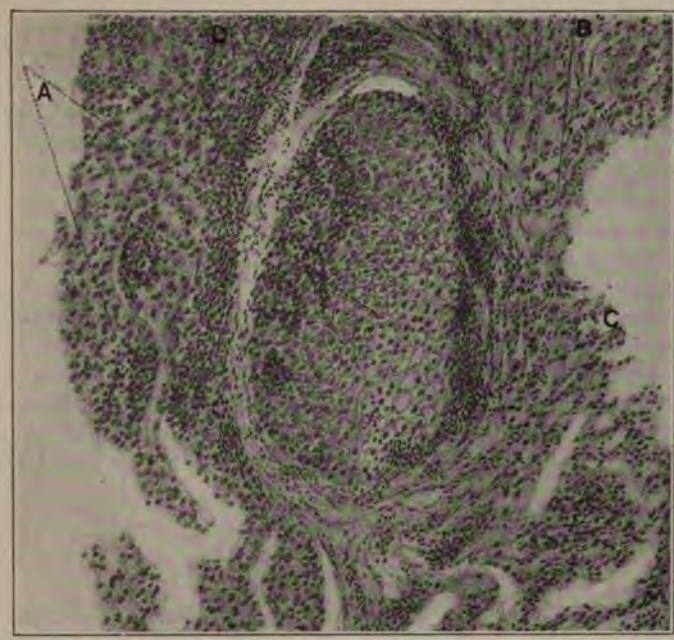


FIG. 150.—Mrs. H. Carcinoma portis vaginalis cervicis uteri. Low power reproduction of tissue removed February 6, 1915. *A*, squamous-cell carcinoma; *B*, connective tissue; *C*, lymphocytic infiltration; *D*, area reproduced in Fig. 151. (Author's preparation.)

FIG. 151.—High power magnification of area *D* in Fig. 150. *A*, carcinoma cells; *B*, connective tissue. (Author's preparation.)

The cancer cones usually advance into the tissue until they enter blood- and lymphvessels. Some carcinoma elements now become detached from the parent tumor and are rapidly carried along these vessels until they arrive at and are transplanted in distant parts, usually the regional lymph nodes. An obstruction may occur in the lymph stream, whereby a further transplantation in more distant lymphvessels is for the time prevented.

The anatomical arrangement of the lymphatic vessels of the cervix predisposes to the high malignancy of these carcinomata. The lymphvessels pass laterally from the cervix along the uterine artery into the parametrium to the bony pelvis and partly along the sacro-uterine ligaments to both sides of the rectum. Lymph glands are found at the intersection of the ureter and the uterine artery, along the external iliac artery, at the intersection of the hypogastric and iliac arteries and at the posterior pelvic wall lateral to the rectum. They form three lymph gland groups: First, the iliac lymph nodes internal and

FIG. 152.—Sagittal section of cervix, showing a proliferating cauliflower carcinoma of the vaginal portion. (After Winter-Riegel.)

anterior to the external iliac artery; second, the hypogastric lymph nodes internal to the hypogastric artery and vein; and third, the sacral glands at the posterior pelvic wall. The superficial and deep inguinal and the inferior and superior lumbar lymph nodes are not so frequently invaded (see Fig. 161).

Metastases by way of the bloodvessels may occur but they are not so frequently seen as in sarcoma. Should they occur, the cancer cells may also be transplanted along the bloodvessels.

The macroscopic appearance of the cervix carcinomata differs. They are either proliferating, ulcerating, infiltrating or circumscribed growths. The proliferating growth is cauliflower-like, originating from the vaginal surface epithelium. It forms warty excrescences, grows into the lumen of the vagina and does not show any marked tendency to advance into the tissues of the cervix. The surface of the cauliflower tumor is uneven, often necrotic and has an outspoken tendency to invade the vaginal walls. Such an extension may not

occur in continuity but result in the formation of apparently many isolated growths within the vagina (see Fig. 152).

FIG. 153.—Destructive form of carcinoma of cervix showing cylindrical cell cancer of endocervix.

FIG. 154.—Infiltrating form of squamous-cell carcinoma or vaginal portion of cervix.

The formation of shallow ulcers in the portio is rare. Such ulcers are superficial, have a hard base and raised edges. They do not advance into the deeper tissues and grow very slowly. They resemble the rodent skin ulcers and are chiefly observed in older women.

The most frequent form is the medullary, infiltrating carcinoma derived from both the vaginal and cervical mucous membranes. It only grows into the tissues, forms hard masses, which finally disintegrate from the surface inward, resulting in deep crater-like ulcers with ragged edges which bleed easily and profusely. This form of tumor develops very rapidly, early infiltrates the parametrium, soon forms metastases in the regional lymph nodes and rapidly invades the neighboring organs as the bladder and rectum (see Figs. 153 and 154).

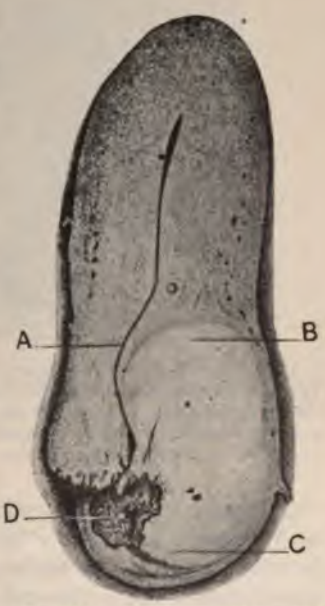


FIG. 155.—Scirrhus carcinoma of cervix. Advanced stages showing beginning necrosis. Tumor is well defined. *A*, internal os uteri; *B-C*, extent of tumor; *D*, area of necrosis.

A circumscribed scirrhus carcinoma has been observed which grows very slowly, due to a simultaneous proliferation of its connective-tissue stroma. It forms a hard firm growth, causing unevenness in consistency of the cervix. It does not disintegrate, but bleeds easily on being touched (see Fig. 155).

It is very difficult to decide from which portion of the cervix a cancer originated, because we see these cases mostly in an advanced stage. It is, however, probable that cauliflower tumors, rodent ulcers and circumscribed scirrhus cancers are derived from the squamous epithelial cell surface. They grow slower and do not invade neighboring organs and tissues like the medullary, disintegrating and infiltrating forms which usually develop from the glandular mucosa of the cervical canal. The former also are less malignant than the latter.

FIG. 156.—Section from diagnostic curettage obtained October 21, 1914. Miss I. B., Washington Boul. Hospital No. 3969. Ocular 10, eyepiece 16 mm., tube length 160 mm. An adenocarcinoma corporis uteri. *A*, carcinoma cells; *B*, connective tissue; *C*, bloodvessel. Carcinoma tissue has almost entirely displaced the normal parenchyma. (Author's preparation.)

The extension of the cancer, after it has involved the entire cervical wall, usually takes place laterally toward the parametrium, anteriorly in the utero-vesical septum and bladder and posteriorly along the sacro-uterine ligaments and the rectum. A carcinoma situated in the most dependent parts of the collum usually involves the vaginal walls and then the bladder anteriorly and the rectum posteriorly. While a cancer located in the upper portion of the cervix tends to invade the corpus, usually the myometrium, more rarely the endometrium. Such a tumor may obstruct the lumen of the cervical canal, causing retention of a purulent secretion within the uterine cavity (pyometra). The farther a carcinoma has advanced in its growth, the more frequent and extensive are glandular metastases.

Corporeal carcinomata are usually of the glandular variety. We may find a pronounced proliferation of the glands with an atypical multiplication of the epithelium. The glands show either an everting or inverting form. The epithelial cells, as well as the nuclei, are irregular in form. There is an abnormal mytosis of nuclei, an irregularity in staining qualities of the nuclei (chromatosis), rupture of the membrana propria of the glands, atypical destruction of the underlying tissues and so forth. A metaplasia of cylindrical epithelial cells into squamous epithelial cells may occur, but it is extremely rare (see Figs. 156 and 157).

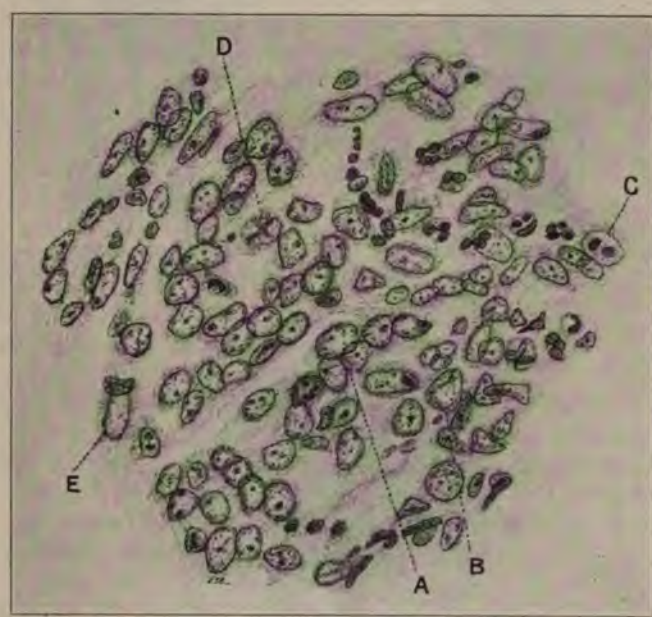


FIG. 157.—High-power magnification of an area in Fig. 156. Ocular 10, eyepiece 4 mm., tube length 160 mm. This preparation shows cell division at *A*, vacuolation at *B*, mitosis at *C* and *D* and necrotization at *E*. The proliferative activity of the cancer is, therefore, very evident. (Author's preparation.)

Glandular metastases occur very late in body cancers. The lymph-vessels of the body of the uterus are divided into two groups. One set travels along the broad ligament to the bifurcation of the abdominal aorta and terminates in the lumbar lymph nodes. The other passes through the round ligament to the superficial and deep inguinal lymph glands. These lymph glands also communicate with the iliac lymph node group by anastomosis (see Fig. 161).

The macroscopic appearance of corporeal carcinomata differs. One may see extensive superficial tumors involving the entire endometrium, or irregular circumscribed growths of a firm consistency or of an irregular disintegrating character. In the final stages the entire uterine wall is involved. Disintegration and necrosis of corpus

cancers and also invasion of the parametrium and regional lym glands are not as frequent as in cervical tumors (see Figs. 158, 1 and 160).

FIG. 158—Diffuse carcinoma of endometrium. (After Winter-Richter.)

FIG. 159.—Circumscribed carcinoma endometrium. (After Winter-Richte

FIG. 160.—Section of uterus. *A*, carcinoma; *B*, pyometra; *C*, lower border of pyome

The regional lymph gland groups of the cervix are the parametri the iliac, the hypogastric, the sacral and the inferior and super lumbar, those of the body are the inferior and superior lumbar, t

superficial and deep inguinal and the iliac. Schauta has divided these lymph groups into two classes. First, those which may easily be extirpated, the iliac, hypogastric and sacral, and second those which cannot or may be only removed with great difficulty, the lumbar, celiac, superficial and deep inguinal.

The frequency of the occurrence of glandular metastases has been studied carefully by microscopical examination of glands removed during operation.

Von Rosthorn found carcinomatous glands in 54 per cent.
Funke found carcinomatous glands in 20 per cent.
Wertheim found carcinomatous glands in 33 per cent.
Winter found carcinomatous glands in 35 per cent.
Zweifel found carcinomatous glands in 21 per cent.
Gellhorn found carcinomatous glands in 36 per cent.
Bumm found carcinomatous glands in 32 per cent.
Glockner found carcinomatous glands in 26 per cent.
Kermauner found carcinomatous glands in 52 per cent.
Manteufel found carcinomatous glands in 33 per cent.
Baisch found carcinomatous glands in 33 per cent.
Bonnet found carcinomatous glands in 51 per cent.
Fromme found carcinomatous glands in 36 per cent.
Dittrich found carcinomatous glands in 40 per cent.
Peiser found carcinomatous glands in 50 per cent.
König found carcinomatous glands in 27 per cent.
Richelmann found carcinomatous glands in 57 per cent.

The iliac glands are most frequently infected. Schauta proved this from 60 postmortem examinations in which he observed the iliac glands affected 28 times, the sacral glands 26 times, the lumbar 17 times, the superficial inguinal 13 times, the deep inguinal 11 times and the celiac 9 times.

The tissues surrounding the carcinoma react in different ways depending on the character of the tissue. The stroma shows a round cell infiltration, composed of leukocytic phagocytes and round connective-tissue cells. The latter predominate. The round-cell infiltration is the defense of the organism against the invading enemy. It is densest in the immediate periphery of the growth. The rest of the uterus is in a condition of hyperemia. The reproductions of microscropic sections show this fact very clearly.

Symptoms.—Carcinoma uteri does not cause any especial symptoms in its beginning or incipient stage, and in its advanced stages the cancer has usually extended much further than the symptoms would indicate.

Winter collected data concerning the period from the time of the appearance of the first symptoms of the disease until the time the patient would apply for medical assistance. He observed 1062 cases. Thirteen per cent. were observed during the first month, 30 per cent. during the second and third months, 27 per cent. during the second, 11 per cent. during the third, 12 during the fourth quarter, and 8 per cent. during the second year.

Another question of interest is: How long on an average h
carcinoma existed from the time the first symptoms appeared
it becomes inoperable? Brunet observed that of 168 patient

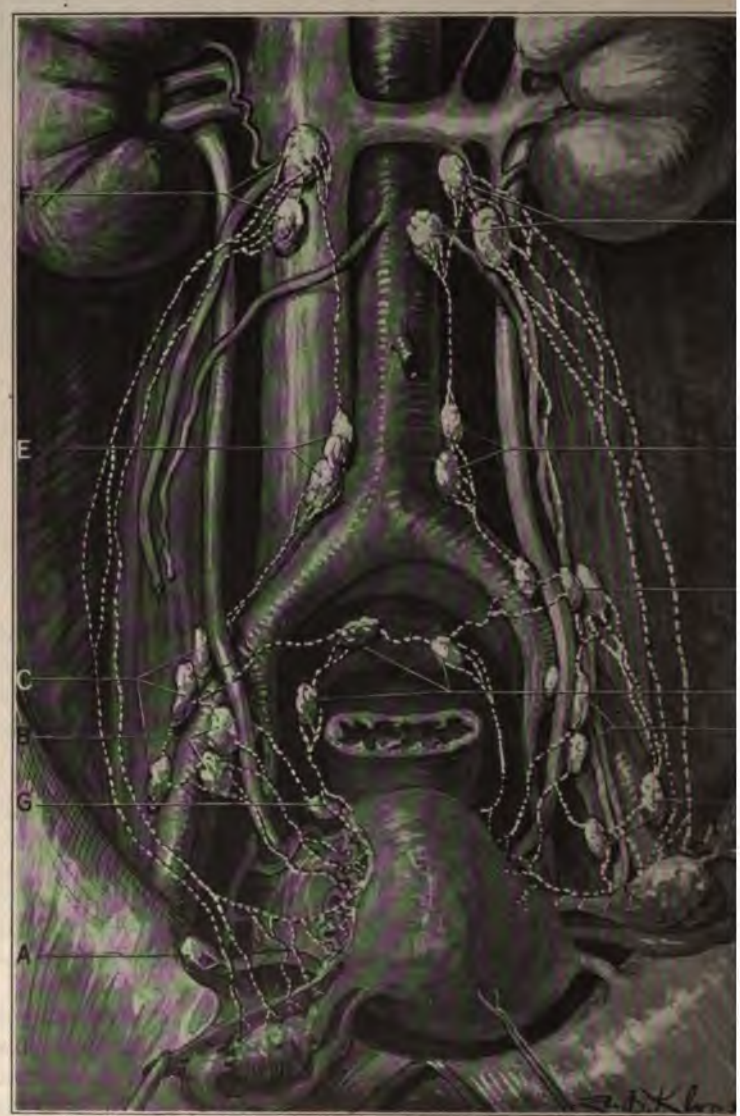


FIG. 161.—Lymph gland groups of the female genitals. *A*, inguinal glands; *B*, gastric glands; *C*, iliac glands; *D*, sacral glands; *E*, inferior lumbar glands; *F*, lumbar glands; *G*, parametrial glands. (After Döderlein-Krönig.)

cervical cancer, 18 applied for treatment during the first four
In over one-half of these cases the cancer had already passed ov
boundaries of the uterus. In 31 cases symptoms had existed f

months and 20 per cent. of these were inoperable. After three months 26 per cent. and after four months 40 per cent. were inoperable. In 70 cases of this group, 13 cases had existed for three months and 86 per cent. were cured, 27 cases for six months of which 31.5 per cent. were cured, 8 cases came for operation during the second half year with 25 per cent. cures and 2 cases came after the first year and both died. In 27 cases of corpus carcinomata that had existed more than half a year, only 4 showed that the disease had transgressed the boundaries of the uterus.

The average duration of carcinoma of the uterus, if left to itself, depends on the location of the growth, the variety of cancer, the age and physical condition of the patient, the complications and finally the various symptomatic treatments employed. A soft medullary cancer causes death sooner than a scirrhus or cancroid. The cervical cancers terminate sooner than corporeal. Young and pregnant women also succumb sooner than senile women with hard contracted tissues. The average duration of cervical carcinomata is from one to two years and of corporeal from two to three years.

The symptoms of uterine carcinomata may be divided into four classes:

1. Those due to the local uterine disease.
2. Those depending on the involvement of neighboring organs.
3. Those due to metastases in distantly located organs.
4. Those due to interference of the general health of the patient.

The most important symptoms due to the invasion of the uterus are hemorrhage, discharge and pain. The latter usually signifies an infiltration of the parametrium. The discharge appears first, the hemorrhage is the most alarming and the pain the most unfavorable symptom. Of 82 cases coming under my care during the last two and one-half years at the Augustana and the St. Mary's of Nazareth Hospitals, Chicago, 53 applied for treatment on account of uterine hemorrhages, 15 on account of discharge, 9 on account of pain, 4 on account of an existing tumefaction and in 1 case the diagnosis was made by microscropic evidence—the patient consulting the physician on account of deteriorating health.

The discharge depends on the increased epithelial cell proliferation and the coexisting hyperemia of the uterus. At first it is only an increase of the normal secretion. As soon as the bloodvessels become eroded it assumes a pale reddish tinge, and when necrosis and disintegration of the tumor take place, then the discharge turns putrid and finally assumes the well-known cancer odor. It is the duty of the physician correctly to interpret the underlying cause of any existing discharge from the genitalia no matter at what age it occurs.

Hemorrhages are caused by an erosion of the bloodvessels by cancer cells, the periodical hyperemia of the uterus coincident with the menstrual cycle, and finally direct trauma during bimanual palpation, cohabitation and the expulsion of hard constipated feces. They are an expression of the destructive character of the new growth.

Hemorrhages of corporeal cancers assert themselves as menorrhagias. The reappearance of so-called "menses" after cessation of menstrual life always gives rise to suspicions of malignancy.

Pain usually signifies an extension of the growth to the parametrium. It is usually of a gnawing, boring character, due to an involvement of the uterine and periuterine nerve fibers. Intermittent colicky pains often occur in corporeal cancers due to a retention of secretion in the uterine cavity. The expulsion of the contents is accompanied by a contraction of the uterine muscle—"uterine colic." The intermittent, colicky pain, relieved by a profuse purulent, putrid discharge was considered pathognomonic of body cancer by Sir James Simpson.

The most frequent and most important symptoms due to the invasion of the neighboring organs and tissues are caused by an involvement of the genito-urinary organs. They are, pressure in the neck of the bladder, dysuria, opaqueness of the urine, incontinence and finally the formation of a vesico-vaginal fistula. The involuntary escape of urine together with the putrid discharge causes an erythema of the external genitalia and the inner aspect of the thighs, resulting in an unbearable pruritus and excoriation of the skin.

The ureter may be compressed by the carcinoma. The retention of urine causes hydroureter, hydronephrosis, pyelonephritis and finally uremia. The patient complains of pressure pain in the flanks, anorexia and nausea. Finally a semi-comatosis appears terminating in uremia and death.

Involvement of the rectum is not as frequent as that of the urinary organs. Mechanical obstruction appears late in the disease. Obstinate constipation, however, already exists in the beginning of carcinoma uteri and is caused by the digestive disturbances, lessened bodily exercise and voluntary neglect due to the painful defecation. Recto-vaginal fistulæ form rarely. They occur in about 6 per cent. of the cases, while vesico-vaginal fistulæ appear in about 15 per cent., and both are present in about 3 per cent.

Extension of the carcinoma into the parametrium leads to a thrombosis characterized by edema of the vulva and lower extremities and the formation of hemorrhoids. Invasion of the perimetrium and metastases in the free peritoneal cavity cause sharp intermittent pain due to adhesions, and rigidity of the abdominal walls.

Secondary metastatic carcinoma of distant organs is rare in uterine cancer. They occur in the liver in about 12 per cent., in the lungs about 5, pleura 2, kidneys 2, bones 1.5 per cent., and brain .02 per cent. (Willimsky).

General constitutional symptoms appear later in the disease. Such conditions are pyrexia, the result of a secondary pyogenic infection of the necrotic cancer masses, or toxemia, the result of a sapremia. Loss of appetite is due to the terrific cancerous odor in which the patients have to live. Should the latter subside under appropriate treatment, then the normal appetite reappears. Insomnia is very frequent and very often one of the first symptoms.

Cachexia appears in the advanced stages of the disease. The patient loses in weight, the skin turns dry, brittle and pale yellow. The physical strength decreases more rapidly than the mental faculties. About 15 per cent. of uterine carcinoma sufferers die from cachexia and general carcinosis, while at least 50 per cent. succumb to genito-urinary disturbances (Beckman and Simmonds). The cachexia results from defective nourishment, anemia, septicopyemia, sapremia, disturbances of metabolism and hemolytic processes in the red blood corpuscles. It terminates in an auto-intoxication, which invariably leads to a fatal termination.

Diagnosis.—Carcinoma of the uterus in its beginning stage is localized in this organ. A timely eradication of the new growth at this time leads to a complete anatomical recovery. These facts render it imperative that an early correct diagnosis be made. It is our absolute duty to inform our patients of the possibility of the existence of carcinoma if symptoms and signs are present, which may be associated with cancer. We must insist on a correct and immediate diagnosis of such conditions.

The examination must determine:

1. The primary focus of the disease.
2. The structure of the cancer.
3. The extent of the new growth into the neighboring and distantly located organs and tissues, and
4. Complicating diseases.

Diagnosis of carcinoma uteri is in most cases easy. The evidences obtained by inspection suffice if the cervix is the seat of a breaking down tumor, either a proliferating cauliflower-like growth, an ulcer with hard ragged edges, or a deep crater-like, distinctly infiltrating growth.

The diagnosis is difficult if the tumor growth is still very small, or located deep in the tissues, or contained within the cervical canal or uterine cavity. One must, then, insist on the removal of tissue for diagnostic purposes. A. J. Ochsner and others condemn such a procedure stating that they never have seen a patient recover from carcinoma who had been subjected to ever so slight a trauma; that all such patients died as a result of metastatic growths. This objection could, however, be overcome by the immediate application of the cautery iron or a radium capsule. These, certainly, would prevent an undue stimulation of the growth on account of such trauma.

One should treat a carcinoma only after a positive diagnosis. This axiom must be applied to all diseases of the uterus accompanied by leucorrhea, hemorrhage or pain. These conditions should never be treated unless a correct diagnosis of the underlying disease has been made. The history, in each instance, is of great importance in rendering a diagnosis.

Bimanual palpation enables us to establish the extent of the tumor. A decrease in movability of the uterus indicates an invasion of the regions immediately surrounding the organ, while a fixed uterus indi-

cates an advanced stage of the disease, though fixation and decreased movability may result from a coexisting infection.

An extension of the carcinoma to the parametrium and the hypogastric and external iliac lymph nodes may be easily elicited by a recto-abdominal palpation. Invasion of the rectal wall is corroborated by evidence obtained by the use of a rectoscope which will show edema of the mucosa, hyperemia, eventually tumor formation and in advanced cases, destruction and necrosis of the rectal wall. The extent of the disease upward into the cavity of the uterus may be determined by the uteroscope. Evidence of the involvement of the bladder, the extent and nature of the same, also invasion of the ureter, is best obtained by a cystoscope, while changes in the urethra are elicited by a urethroscope. The results obtained by endoscopic examinations are surprising and of great assistance in determining the extent of the cancer disease. They corroborate the signs obtained by the usual physical examination. Bimanual examination of the uterus in carcinoma of the corpus reveals a globular shaped body; 8 to 11 per cent. of uterine carcinomata are corporeal.

Finally attention must be given to the microscopic diagnosis. MacCarty divides the stages of epithelial hyperplasia into primary, secondary and tertiary, or migratory, hyperplasia. The primary proliferations are benign, the secondary are doubtful and potentially malignant, and the tertiary are malignant epithelial growths. The epithelial cells in the first two are located intra-acinic and intraglandular and in the tertiary they are extraglandular, *i. e.*, migratory. The secondary stage is a precarcinomatous condition. If we apply this observation to diffuse neoplastic conditions, a microscopic diagnosis should not be difficult.

Certain laboratory tests have been advocated in the verification and corroboration of the clinical diagnosis and also in aiding the differential diagnosis. These are Abderhalden's blood serum diagnosis, the Wassermann reaction, the tuberculin test and the meiostagmin test. Negative results, however, do not permit us to exclude any one of the diseases, that must be considered in the direct and differential diagnosis.

The differential diagnosis of carcinoma of the cervix comprises chancre, tuberculous affections, cervical erosions, inflammatory hyperplasia, sarcoma, myoma and pedunculated mucous polypi. The history of the cases, the symptoms, the objective findings, the laboratory diagnosis and the microscopic and serum tests, will aid us in a correct differentiation of these conditions.

Corpus cancer must be differentiated from sarcoma, chorionepithelioma malignum, uterine myomata, tuberculosis, myomatosis uteri, hemorrhagic metropathy, chronic endometritis, pregnancy in the first trimester, abortion and para- and perimetritides. Here, also, the same rules for differentiation must be applied as mentioned in the preceding paragraph.

Treatment.—For the correct treatment of carcinoma of the uterus it is necessary to consider the following five factors:

1. Whether the growth is still confined within the boundary of the organ.
2. The extent of the infiltration of the surrounding tissues and organs, *i. e.*, if the cancer is no longer localized.
3. The degree of metastazation of the regional lymph glands.
4. The existence of secondary growths in distant organs.
5. The condition of the state of general health of the patient.

The first factor renders a carcinoma of the uterus operable, for we may hope for a complete anatomical eradication of the growth. The second and third factors render the disease still operable, although only rarely with a hope of producing a permanent cure, if we are able to remove by a more extended operation all of the invaded structures, namely, the parametrium, the invaded portions of the bladder, ureters or rectum, together with the "first line" of glands if they are involved. These include the parametrial, iliac, hypogastric and sacral lymph gland groups. Such carcinomata are borderline, and hence doubtfully operable cases.

However, should the extent of the involvement render such a radical procedure impossible due to technical difficulties or the inability of the patient to survive such an extended operation, or should the "second line" of glands be involved, *i. e.*, the lumbar, celiac and superficial and deep inguinal glands, then the case becomes inoperable. The fourth factor renders any surgical procedure absolutely hopeless. While the fifth factor may give a contra-indication to any operation even if the first and second factors would otherwise render the disease operable. Such constitutional conditions are: advanced cachexia, a low hemoglobin percentage (50 per cent. or less), a severe degree of secondary anemia, the erythrocyte count being two millions or less, a blood-pressure of 90 or lower, diabetes, tuberculosis, Bright's disease, etc. But even though the patient is subject to any one of these ailments, the outlook of the case may be improved by transfusion of massive doses of whole blood as practiced and advocated by N. M. Percy. This procedure is especially advisable in severe cases of anemia due to repeated hemorrhages in carcinoma confined to the cervix, low blood-pressure, and occasionally in advanced cachexia, where it seems desirable to prolong life although there may be no likelihood of a permanent cure. Hence we may state the treatment of carcinoma of the uterus to be, first, curative and, second, palliative. However, to a certain degree it must also be prophylactic.

Clinical experience teaches us that certain chronic diseases of the uterus and long continued mechanical local irritations predispose to cancer disease. Chronic irritation plays an important role in the production of carcinoma. The diseases causing them have been termed "precancerous states." The essential characteristics of these precancerous states are profuse leucorrhea and meno- and metrorrhagias. Chronic diseases characterized by these two symptoms are chronic salpingitis, chronic endometritis and myometritis, chronic endocervicitis and pancervicitis with ectropion of the cervical mucosa, cervical

erosions, lacerations of the cervix with eversion of the cervical mucosa and formation of scar tissue, and finally malpositions of the uterus, causing chronic endometritis and cervicitis. It becomes our imperative duty to insist on a treatment of all of these conditions until a perfect cure is obtained. Such treatment comprises the "prophylaxis" of cancer disease and demands a careful examination of all patients coming under our observation. A timely correction of such diseases would prevent many a case of malignancy in later life.

Methods of Treatment.—The methods of curative treatment of carcinoma uteri are chiefly vaginal and abdominal panhysterectomies and the abdominal radical extirpation of the pelvic organs, namely, the "Wertheim" operation. The question arises, what indications determine the use of these different methods? Some surgeons deem the vaginal operation sufficient. It has the advantage of a low primary or operative mortality and can be used in many cases which would otherwise be poor surgical risks, for instance in obese, advancedly cachectic and severely anemic women and in cases of corporeal cancer.

The abdominal methods differ in their primary mortality and remote efficacy. The abdominal panhysterectomy has a low primary mortality but fewer permanent cures; while the "Wertheim" operation has a primary mortality of about 25 per cent. and a curative result of about 15 per cent. Hence it would seem that the advantage gained by the latter method is nullified by the high primary mortality. After the results of both abdominal operations have been compared from these points of view, the permanent results are about equally distributed.

The technic of the vaginal and abdominal panhysterectomies has been given in other sections and therefore I will only describe the technic of the "Wertheim" operation. One very important point must be brought out at this time, namely, the separation of the cervix from the vagina must always be performed through the latter canal, no matter whether an abdominal or vaginal removal is contemplated. Furthermore this step of the operation must be done with the electrocautery knife, never with scissors or the ordinary scalpel.

Operations for the eradication of carcinomatous uteri must be preceded and followed by a thorough course of actinotherapy, that is, the combined use of the roentgen and radium rays. I shall discuss this phase of the treatment later.

The determination of the extent of the carcinoma is often difficult and cannot be rendered until the abdomen has been opened. Really every doubtful case should be subjected to an exploratory laparotomy to determine the possibility of a safe removal of the invaded organs, tissues and glands.

The first operation for the removal of the carcinomatous uterus was a vaginal panhysterectomy performed by N. Sauter in 1822. This method underwent a period of continued improvement until Czerny established it as a permanent, classical operation in 1879. in 1886 Richelot advised all substitution of clamps instead of ligatures.

Mackenrodt advocated the exclusive use of the electrocautery instead of the knife and scissors to prevent recurrences by transplantation of tissues, that is, autovaccination. There can be no doubt that this plan increased the percentage of permanent cures.

Vaginal panhysterectomy may be used in beginning corporeal and cervical carcinomata. It, however, has been superseded by the abdominal panhysterectomy which was first used and described by W. A. Freund in 1878. The principle of this operation as executed at present is practically the same as that advocated by Freund. In the course of time, however, many improvements have been added, notably by the labors and researches of Stimson, Polk, John J. Clark, Rumpf and Emil Ries. Stimson taught the separate tying of the uterine artery. Polk advocated this procedure and also promulgated the vaginal drainage as taught by Bardenheuer in 1881 and the use of the Trendelenburg posture. Clark and Rumpf insisted on an extended removal of the parametrium, while Emil Ries advocated the necessity of extirpation of the regional lymph glands (1895). Finally Wertheim and Bumm by their persistent work developed the method generally used at present.

The methods for the preparation of the patient, the administration of the anesthetic, the disinfection of the vagina and the abdominal field of operation have been discussed in their respective chapters. It is, therefore, not necessary to again dwell on these points.

Special attention also must be given to the prevention of the many dangers of this operation. The chief ones are: Sepsis, shock, pulmonary complications and intestinal disturbances.

The best means of preventing sepsis is the careful cauterization of the cervix immediately preceding the abdominal operation. The thorough cauterization also prevents the possibility of a recurrence in the parametrium as well as in the vagina. The best method is the cauterization with the red-hot soldering iron. The vaginal walls are protected with layers of gauze wrung out in cold sterile water, or with strips of sterilized asbestos. These are held in place by four retractors, one anteriorly, one posteriorly and one on either side. A tubular vaginal water-cooled speculum as advocated by J. F. Percy is very practical. The cauterization must be done slowly and thoroughly. The heat should penetrate as deeply as practicable. The cauterization is then followed by a circular incision with the cautery knife at about midway of the vagina, and the vaginal vault and cervix are separated from the underlying structures upward to about a level with the internal os uteri. Bleeding from the cervical and vaginal branches of the uterine arteries is controlled by ligation, cautery or clamp. If clamps are used they are left *in situ* for forty-eight hours. After thirty-six hours the jaws are separated one or two notches. Should bleeding ensue after separation of the jaws the clamp must be immediately closed. After the completion of the vaginal part of the operation, the patient is put in the Trendelenburg posture and the abdominal operation begun.

It is customary in a number of clinics to have this introductory
of the operation executed by a different set of surgeons, assis
nurses and in another operating room.

The usual incision is the median, extending from the symp
pubis to, or slightly above, the umbilicus. The edges of the wou
protected by gauze pads or towels held in place by towel clam
avoid infection of the incision with bacteria and carcinoma ele
The intestines are held back by one very large compress three
long, six inches wide and about sixteen layers in thickness. A ret

FIG. 162.—The radical operation of cancer of the uterus, after Bumm. Pr
of the abdominal parietes. This and following reproductions represent the
followed by Bumm.

is inserted above the symphysis pubis to keep the bladder out
field of operation. The abdominal walls are retracted to one
other side corresponding to the side of the uterus under diss
(see Fig. 162).

A vulsellum forceps is applied to the corpus uteri, or two are
one on each cornu, and the uterus drawn downward and towar
right (see Fig. 163). The left ovarian bloodvessels are clamped
to the bony wall of the pelvis, severed and ligated with plain c
Catgut is the preferable suture and ligature material for the oper

The uterus is now pulled upward and to the right. The anterior layer of the broad ligament is incised along a crescent-shaped line extending to the left termination of the vesico-uterine plica. See Fig. 164. The distal end of the round ligament is ligated. The broad ligament is dissected off the parametrium downward by blunt dissection until the left ureter is found. The ureter is exposed by blunt dissection to its insertion in the urinary bladder. Next the left uterine and the superior vesical arteries are located and freed downward to the bladder, medially

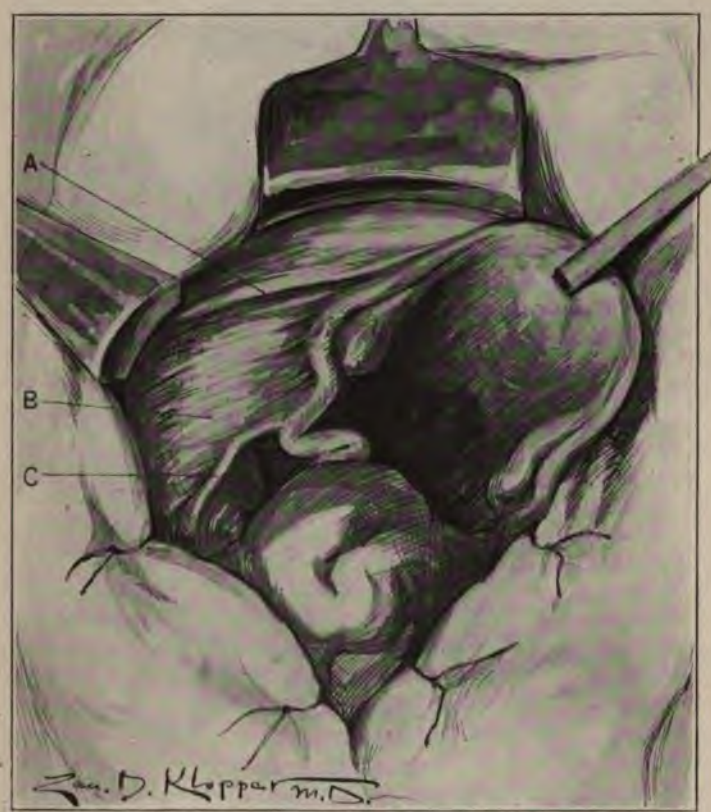


FIG. 163.—Exposure of the field of operation on the left side. *A*, round ligament; *B*, suspensory ligament. *C*, ovarian bloodvessels.

to the uterus, and upward to the hypogastric, and the latter to the bifurcation of the iliac artery. The uterine artery is ligated close to the superior vesical artery. Care must be taken not to injure this bloodvessel. Such an accident might lead to a necrosis of part of the urinary bladder.

The exposure of the ureter may cause great, and at times unsurmountable difficulties. It should be performed by blunt dissection. If this is impossible a forceps should be attached to the stump of

the median portion of the uterine artery and traction made upward better expose the ureter which now may be freed by blunt gauze dissection or by sharp dissection with scissors. It is best not to ligate the uterine vein at this stage of the operation. Should it become accidentally injured, it is best to apply pressure by packing a gauze pad into the bottom of the wound cavity (see Fig. 165).

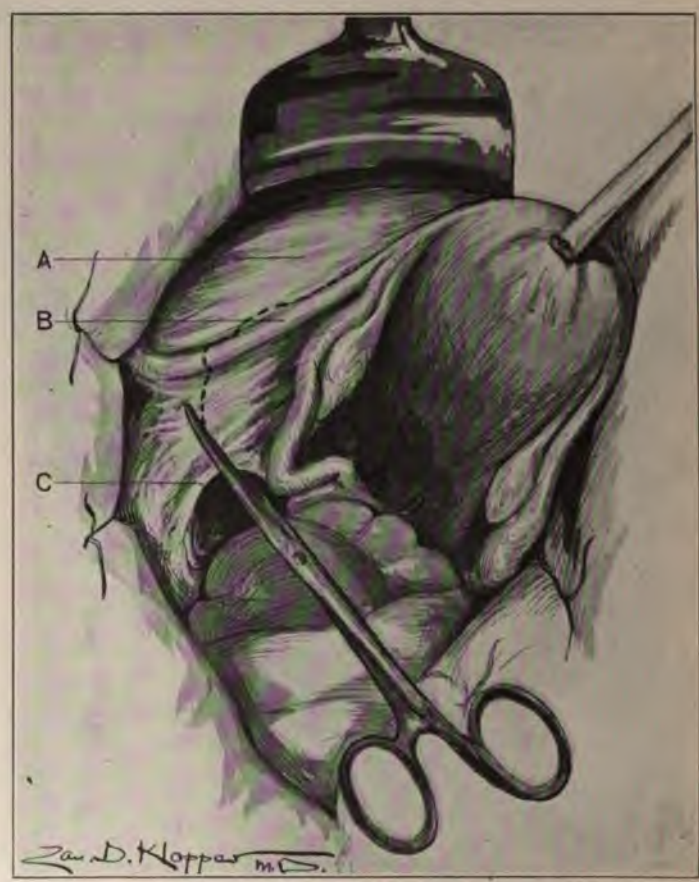


FIG. 164.—Clamping of the ovarian vessels. Line of incision over the anterior peritoneal layer of the broad ligament. *A*, bladder; *B*, round ligament; *C*, ovarian bloodvessels.

The same procedure is then followed on the right side (see Fig. 166). At the completion of this step of the operation the incision between the right and left anterior incisions is carried across the vesico-uterine plica (see Fig. 167). The bladder is pushed away from the anterior wall of the uterus until it meets the opening made with the electrocautery knife per vaginam. Thereby a communication with the vagina is established through which a strip of yellow (iodoform) gauze twelve inches wide and one yard long is pushed with a curved

preferably uterine, sound to remove any secretion or other material down into and out of the vagina (see Fig. 170).

The recto-vaginal septum is loosened by blunt dissection laterally, upward and downward, until the posterior vaginal wall is freed to the incision made in the first stage of the operation per vaginam. The dissection is carried upward to detach the Douglas's peritoneum from the underlying rectum. The uterus is then pulled toward the symphysis

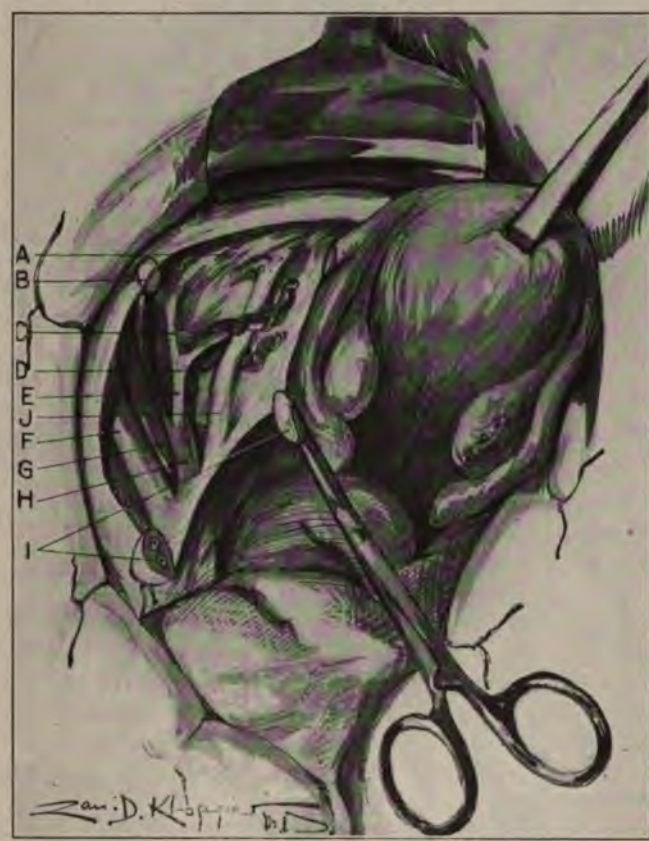


FIG. 165.—Regional anatomy of the field of operation after separating the layers of the broad ligament. *A*, bladder; *B*, round ligament; *C*, superior vesical artery; *D*, deep uterine vein; *E*, uterine artery; *F*, external iliac artery; *G*, external iliac vein; *H*, hypogastric artery; *I*, pedicles of ovarian vessels; *J*, ureter.

pubis. An incision is carried along the posterior layer of the broad ligament from one pedicle of the ovarian vessels downward to the level of the separation of the Douglas's pouch from the rectum to the opposite pedicle of the ovarian vessels (see Figs. 168 and 169). One must bear in mind not to injure the ureters and, since they have previously been exposed, this accident ought to be easily avoidable. This step of the operation differs from the one given by Bumm. The illustrations

show the latter's technic. Traction on the uterus exposes the par metria which are dissected off the bony pelvic wall by blunt dissectio The parametrium first to be severed is the one least infiltrated. Blee ing areas are grasped with clamps. As soon as the uterus and par metria have been removed in one mass, the bleeding points are ligat (see Fig. 171).

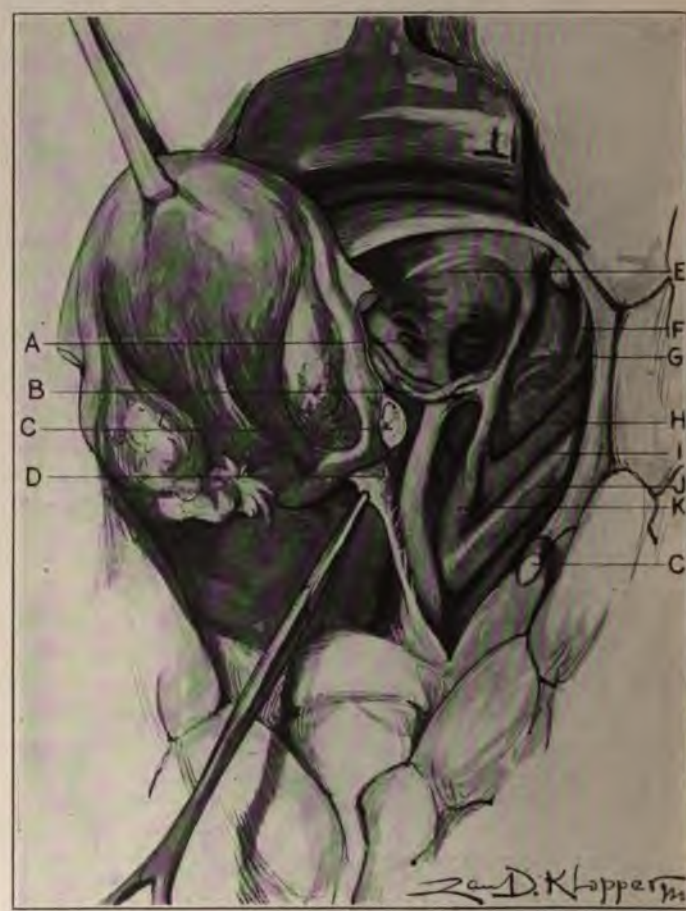


FIG. 166.—Regional anatomy of field of operation on the right side showing bifu tion of common iliac artery. *A*, right ureter; *B*, uterine artery and vein; *C*, pedi of ovarian vessels; *D*, median fold of the broad ligament; *E*, bladder; *F*, obturator ner *G*, superior vesical artery; *H*, trunk of uterine artery; *I*, external iliac vein; *J*, exter iliac artery; *K*, hypogastric artery.

The next step of the operation is the removal of the hypogast and iliac lymph glands and any fatty tissue still remaining in the bott of the wound cavity. They are best attacked by dry gauze dissecti Care must be taken not to injure any bloodvessels, particularly veins. All bleeding points must immediately be secured by ligatu

The final step of the operation consists in the closure of the wound surfaces. The posterior bladder wall is covered by uniting the peritoneal cover of the bladder to the anterior vaginal wall with interrupted catgut sutures. The anterior rectal wall is similarly covered by attaching the posterior peritoneal flap to the posterior vaginal wall (see Fig. 172).

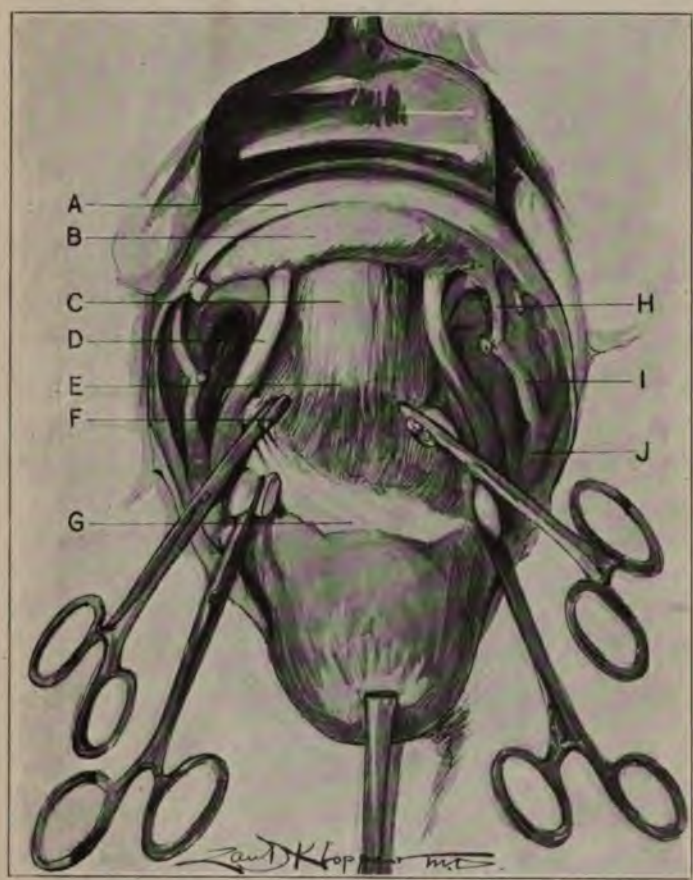


FIG. 167.—Regional anatomy after exposure of both ureters and separation of bladder. *A*, peritoneum; *B*, bladder; *C*, vagina; *D*, left ureter; *E*, cervix; *F*, pedicle of uterine vessels; *G*, edge of peritoneum; *H*, superior vesical artery; *I*, trunk of uterine artery; *J*, hypogastric artery.

If hemostasis is absolute, complete drainage does not become necessary. But if the slightest doubt exists or infection is probable, drainage must be employed. A strip of iodoform gauze twelve inches wide and two yards long is folded on itself. The middle portion is packed down into the vagina and each end is made to cover the raw surface of the floor of the bony pelvis on either side (see Fig. 172). The anterior parietal peritoneum is united to the posterior parietal layer with a

continuous catgut suture beginning at either ovarian pedicle. The bladder peritoneum is joined to the Douglas peritoneum leaving a space underneath sufficiently large for drainage (see Fig. 173). Finally the appendix is removed, the bowels are replaced and the omentum drawn over the intestinal loops. The incision in the abdominal wall is closed in the usual manner and a dressing applied.

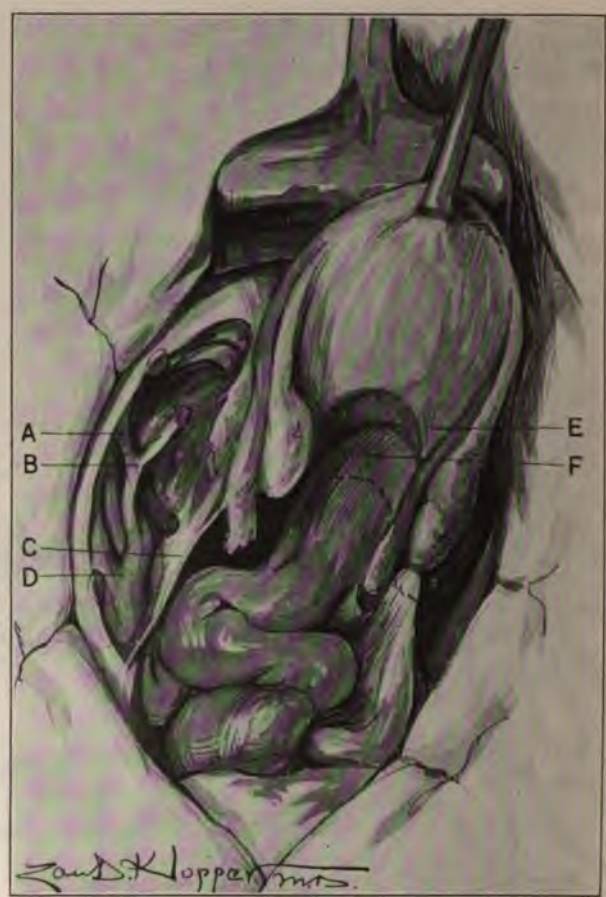


FIG. 168.—Line of incision over posterior fold of the broad ligament and of the recto-uterine pouch (shown by dotted line). *A*, superior vesical artery; *B*, uterine artery; *C*, ureter; *D*, bifurcation of the iliac artery; *E*, fold of excavatio recto-uterina; *F*, recto-uterine pouch.

A retention catheter is inserted into the bladder to remain for five to eight days. A perineal pad is applied and held in place by a T-binder. Finally the stomach is irrigated, if inhalation anesthesia has been used, to remove all ether which the patient may have accidentally swallowed and thus prevent postoperative dilatation of the stomach due to paresis of its walls. A normal saline transfusion or,

if the patient is a poor surgical risk, a transfusion of massive doses of whole blood is immediately given. The patient is returned to bed, the head of the bed being elevated from six to eight inches. The patient must remain in blankets and be surrounded by artificial heat until

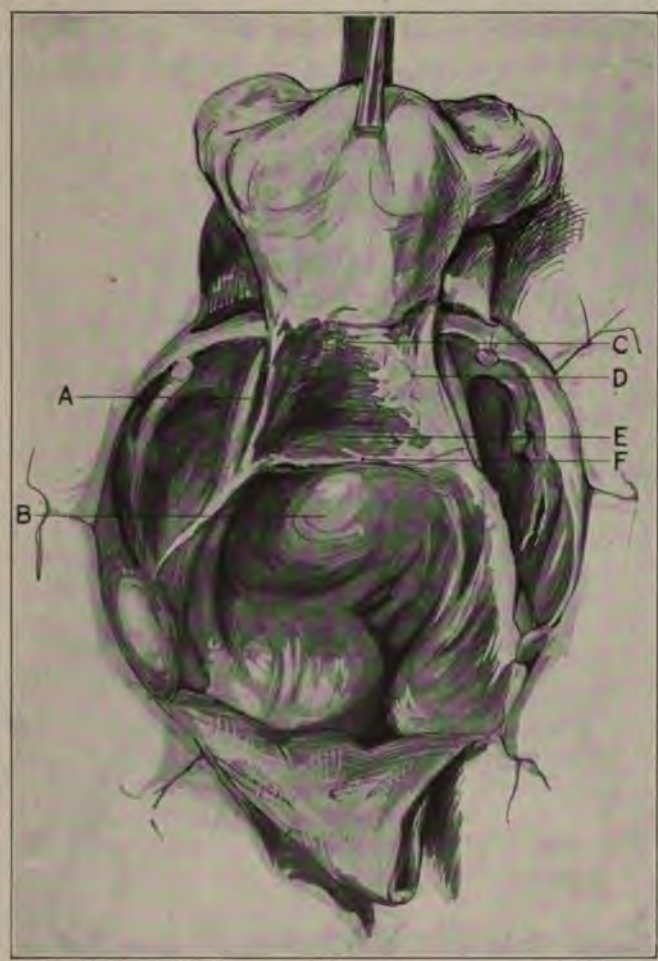


FIG. 169.—Pushing off of rectum. Exposure of the cardinal ligaments. *A*, ureter; *B*, rectum; *C*, cervix; *D*, cardinal ligaments; *E*, wall of rectum; *F*, border of Douglas's peritoneum (posterior layer of recto-uterine pouch.)

proper body-reaction ensues indicated by profuse perspiration. Heart-failure is combated with saline transfusions and the hypodermic injection of 0.5 to 1 c.c. doses of digalen.

The gauze drain should remain for five days after which time a short piece of about six inches in length is removed daily. To prevent any bladder complications 0.5 gm. urotropin dissolved in a glass of distilled cool water is given three times daily, or 1 c.c. of dilute sulphuric acid

in a wineglassful of water every four to eight hours. It is import to recognize a clogging up of the catheter in due time to obviate undue distension of the bladder with urine. Therefore the nurse m record the amount of urine passed for each subsequent two hours. urine was not voided during any given two hours' interval, a b acid bladder irrigation should be given to remove the obstruction pr ent in the catheter. If the irrigation is unsuccessful the retenti

FIG. 170.—Application of clamp to vagina. Amputation of vagina. *A*, vagin *B*, bladder; *C*, ureter; *D*, parametrium.

catheter must be removed, cleansed, sterilized and reinserted w strictest aseptic precautions. Should anuria exist due to renal function, the patient must be wrapped in warm moist packs and cups or leeches applied over the region of the kidneys.

Pain and great restlessness are relieved by the subcutaneous admi tration of morphine. Should vomiting continue for more than twe hours gastric lavage will assist in stopping it. This treatment sho also be given in case even a slight amount of tympanites occurs at a

time after the operation. The water used for gastric lavage should be heated to 105° F.

Sips of hot water are given by the mouth during the first forty-eight hours following the operation if nausea has subsided. Thereafter small amounts of water at room temperature are given hourly.

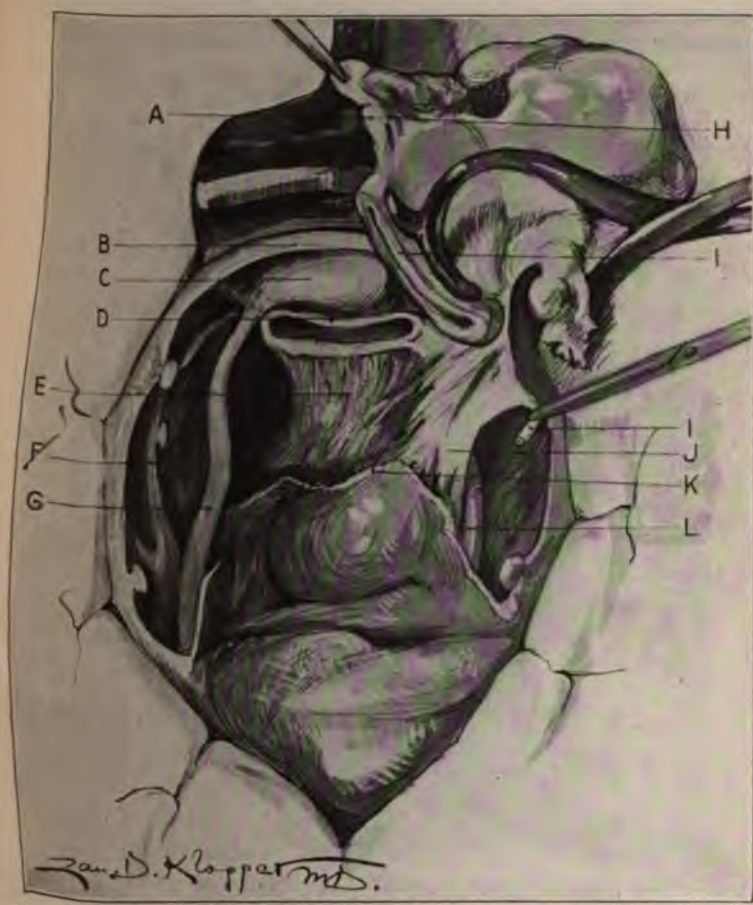


FIG. 171.—Extirpation of the parametria. The left parametrium has been severed. The base of the right parametrium is exposed. *A*, left parametrium; *B*, peritoneum of bladder; *C*, bladder; *D*, vagina; *E*, rectum; *F*, uterine artery; *G*, ureter; *H*, left uterine artery; *I*, right uterine artery; *J*, parametrium; *K*, border of Douglas's peritoneum; *L*, posterior root of parametrium.

Excessive tympanites is relieved by gastric lavage and simple soap-suds enemata. No nourishment should be given by mouth until the tympanites has subsided. The patient may be nourished in the meantime by the use of rectal feeding. If relief is not felt after a simple soap-suds enema, combination enemata must be given. As a last resort an enema of molasses and milk in equal parts is ordered, which usually

is followed by decided results. Cathartics in any form are not administered per oram until the eighth day. Liquid diet is ordered as soon as the enemata return fecal contents; soft diet on the eighth day and a light tray on the tenth day. General diet is ordered when the patient is able to be up and about which should be about the fourteenth day.

Complications during the operation arise from accidents to, or involvement of the ureters, bladder and rectum with carcinoma. Should the ureter become injured close to its insertion into the bladder, or should

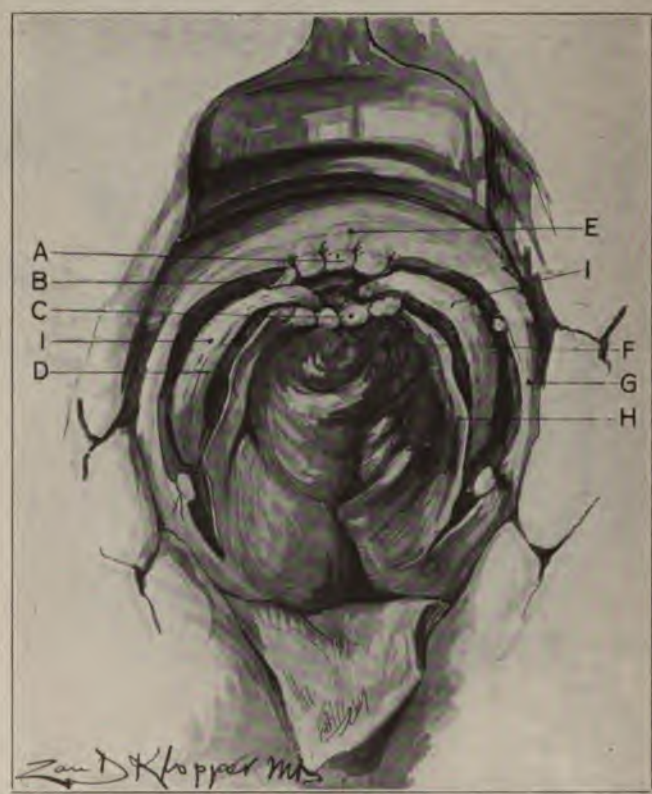


FIG. 172.—Suturing of anterior vaginal wall to bladder peritoneum and posterior vaginal wall to Douglas's peritoneum. Insertion of gauze drain. *A*, anterior vaginal wall; *B*, ureter; *C*, posterior vaginal wall; *D*, parametrial wound cavity; *E*, peritoneum of bladder; *F*, peritoneum of Douglas; *G*, lateral border of the broad ligament; *H*, median border of broad ligament; *I*, gauze drain.

it be involved with carcinoma, and, therefore, must be removed, an incision is made in the fundus of the bladder wall and the proximal end of the ureter inserted through it into the bladder for a distance of 1 to 1.5 cm. It is then carefully secured by fine chromic stitches which enclose all of the bladder wall except the mucosa, and likewise all of the ureteral wall except the mucous membrane. It should then be carefully surrounded with peritoneum so that the latter forms a cuff surrounding the part nearest the bladder.

In case the ureter has been intentionally or unintentionally resected at a place higher up, a uretero-ureterostomy must be performed. The best method is Weller van Hook's. The distal end is severed longitudinally. The proximal end is inserted into the funnel thus formed and carefully secured by interrupted fine chromic catgut or silk stitches. If the ureter was resected to such an extent that uretero-ureterostomy or implantation into the bladder are impossible, then the ends must be ligated and the corresponding kidney left to its fate. Usually the organ ceases to functionate.

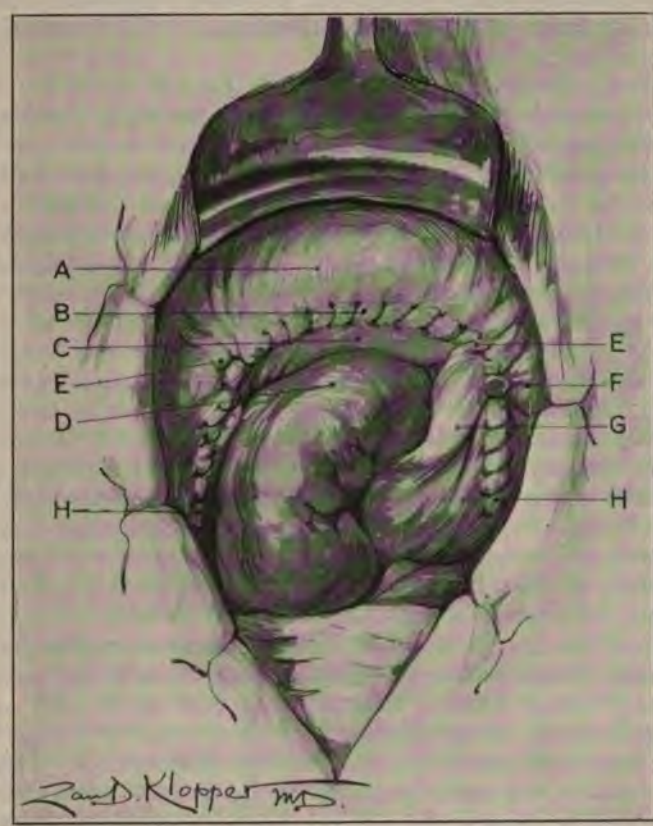


FIG. 173.—Suture and closure of broad ligament. *A*, bladder peritoneum; *B*, vagina; *C*, Douglas's peritoneum; *D*, rectum; *E*, pedicles of round ligament; *F*, lateral fold of broad ligament; *G*, median fold of broad ligament; *H*, pedicles of ovarian bloodvessels.

If a separation of the uterus from the bladder becomes impossible a considerable portion of the vesical wall may be excised. Such defect and other accidental perforations of the vesical wall are closed in the manner described for the repair of vesical fistulæ. If the defect is small, a purse-string suture will close the opening, but if the defect is large, interrupted sutures should be employed in the direction of least resistance. These sutures must penetrate the bladder wall down to the

mucosa but should not include the latter. Stitch fistulæ or stone formation might result.

Rectal fistulæ usually tend to close spontaneously. Involvement of the rectum with cancer, however, demands resection. A Kraske operation, attaching the edge of the proximal portion to the distal portion, or an insertion of the upper end into the lower stump, or an end to side anastomosis, or an inguinal colostomy may be performed. The procedure of choice depends solely upon the conditions present.

Complications following the operation are shock, acute dilatation of the stomach, hypostatic pneumonia, pulmonary embolism, infection of the genito-urinary tract, sepsis and hemorrhage. They are combated in the usual manner.

In spite of the most radical procedures one can never be certain whether a complete removal of all the carcinoma tissue was obtained or whether an implantation of carcinoma elements did not occur during the progress of the operation. Both factors will lead to a recurrence of the carcinoma. To obviate this we invariably take recourse to actinotherapy. One hundred milligrams of radium element properly screened, are inserted into the uterine canal and against the cervix and involved vaginal parts for about eight to ten hours within eight to ten days prior to the date of operation. At the same time from thirty to fifty erythem doses of hard filtered rays are given suprapubically and perineally through about fourteen portals of entrance. As soon as the drain has been removed from the vagina and within about two weeks following the first course of radiation treatment another series of radium and roentgen rays are given. The technic of the latter is given on page 563. Actinotherapy is destined to improve the efficacy of the surgical procedure according to the most recent reports of investigators in this field of treatment. (See reports by Wickham and Dégrais, Krönig and Gauss, Bumm, Döderlein, Kelly and Burnham, and Schmitz.)

The question has been debated since time immemorial whether other modes of treatment exist which also might render the carcinoma harmless. It is clear that if the enormous proliferating power of carcinoma cells could be inhibited or even destroyed, the tumor would become inert and made to disappear by phagocytosis. That the animal organism may create or possess such protective agents has been demonstrated in innumerable clinical examples, where patients have spontaneously recovered from cancer disease, either temporarily or permanently. Abderhalden's serum diagnosis enables us to demonstrate the presence of a specific enzyme in the blood of cancer patients, which is able to digest or devour carcinoma tissue. As long as this protective power of the organism can hold the proliferating power of carcinoma cells in equilibrium the tumor remains dormant or latent. Ehrlich taught that tumors arise from a decrease of the avidity of normal cells and not by an increase of the avidity of the tumor cells. The normal cells of an animal, physically well, have a natural resistance against invading cancer cells. They may prevent or delay the

growth of the tumor, even destroy it, and the organism will only succumb when the enemy becomes too numerous or the production of toxins too great. Any therapeutic agent that could reinforce or actuate such antibodies would to that degree become curative. However, clinical experience has undoubtedly proved that surgical eradication of cancer tissue can give the patient the only assurance and certain possibility of a permanent recovery.

Palliative Treatment.—The palliative treatment of carcinoma of the uterus is symptomatic. We endeavor thereby to restore the patient to as normal a state of health as possible. The only curative treatment is, of course, a surgical eradication of the tumor, as described in the preceding section.

The treatment of inoperable, and therefore incurable carcinomata, is of great importance. Its purpose is to combat the three cardinal symptoms, hemorrhage, discharge and pain, and thereby prevent the development or reappearance of the other constitutional symptoms, mainly anemia and cachexia.

The means to do this are many. The chief ones are: (1) Cauterization, (2) enzymes and colloids and (3) actinotherapy.

Cauterization of inoperable uterine carcinomata aims at the destruction of as much of the tumor substance as is compatible with the patient's general state of health. The chief agents employed for this mode of treatment are live heat and the electrocautery. The patient is prepared as for any operation. An anesthetic must be given. The vaginal walls are protected with gauze pads wrung out in cold, sterile water, or asbestos plates, held in position with retractors. The latter must be cooled quite frequently to prevent burning of the vagina and vulva. If live heat is applied with an ordinary "red hot" soldering iron, the cauterizing action reaches radiantly all around to the extent of at least several centimeters. Neither the Pacquelin nor the electrocautery methods can give so high a degree of heat as the use of the soldering iron.

J. F. Percy has perfected this method by especially designed instruments. He uses a water-cooled vaginal speculum, and has advised the control of the cautery by inserting the hand through a celiotomy incision into the pelvis and thereby palpating the degree of heat developed in the uterus and surrounding tissues.

A great many laparotomies for carcinoma uteri are exploratory, and, therefore, the advice to control the effect of the heat with the hand is a marked improvement in this procedure. The Mayos have promulgated the ligation of the iliac and ovarian arteries, an operation advocated by Pryor and Krönig in 1902. The "Percy method," therefore, has become quite a formidable operation. Whether the results of the operation justify the efforts is still an open question. It is claimed that thereby many an inoperable case becomes operable.

The after-treatment following the cautery operation is very important. The crater and vagina are firmly packed with iodoform gauze. A retention catheter is inserted into the bladder. The gauze pack

must be removed every other day. The crater is swabbed with tincture of iodine, alcohol or acetone, as advocated by Gellhorn and an iodoform gauze tampon is again inserted. Other cauterizing chemical agents, advocated in place of live heat, are the liquor of iron chloride, a 50 per cent. aqueous solution of zinc chloride, followed immediately by the insertion of sterile, dry sodium bicarbonate, the application of calcium carbide and so forth. Following the application of these remedies, an iodoform gauze tampon is inserted. The eschar, formed by the cautery and the chemical corrosives, becomes detached in about three weeks. A clean, healthy, granulating surface is seen which is best treated by the application of the chemicals mentioned to increase the extent of the destruction of the tumor if advisable. Otherwise it is kept dry by the application of tincture of iodine, alcohol or acetone followed by packing with iodoform gauze. The crater contracts very readily, but soon the proliferation of the tumor may commence again. Another cautery operation may then be performed, or further recourse may be had to chloride of zinc solutions, acetone and so forth.

Many surgeons prefer to precede the cauterization with an excochleation of the necrotic tumor tissues by means of a sharp spoon or curette. It seems to me that such procedure is quite useless, since the soldering iron will effectually remove such tissues. Patients treated by these methods must be kept under continuous supervision. Any recurrences must be immediately and vigorously combated.

Fifty-three cases of inoperable uterine carcinomata were treated with the Percy method at the Mayo clinic. In about 80 per cent. of these cases, freedom of symptoms was obtained for about nine to eighteen months. Seeley reports the postoperative history of 23 patients treated with the Percy method. Of these 15 are dead and 8 are living. Of those who died, 1 lived nineteen months, 1 eleven, 1 ten, 8 four to eight, and 4 less than four months. Gessner observed that scarcely one-fifth of the cases subjected to the ordinary cautery treatment were benefited by cauterization. About one-half showed marked improvement; while in the remainder of the cases, the hemorrhages disappeared but the discharge continued. The general state of health was improved, therefore, in about 75 per cent. The average expectancy of life was about two hundred and twenty-five days; the portio-carcinomata showed two hundred twenty-three and two-tenths, and endocervix-carcinomata three hundred three and nine-tenth days. Nine of the latter survived the cauterization more than two years. Gebauer reports the following results in 58 cases; death ensued within the first half year in 7 patients; within the second half in 19, during the second year in 25, during the third year in 5, during the fourth year in 1, and during the fifth year in 1.

Various biological and chemical substances have been advocated from time immemorial for the palliative treatment of carcinoma uteri. The following agents have been recommended for injection of the tumor; solutions of methylene blue, bichloride of mercury, pyoktanin, absolute alcohol, salicylic acid and for intravenous use electro-cobalt,

electro-cuprol, colloidal selen, Borcholin, etc. Results obtained do not favorably compare with those achieved by the live cautery and roentgen, radium and mesothorium rays.

Several investigators have advocated the use of antitoxins, serums and vaccines prepared for supposedly specific cancer schizomycetes. Coley claims to have obtained 12 per cent. of cures by the use of his serum. Kolischer recently reported surprising results from the use of an autolysin. All these attempts are in their infancy, yet possess a scientific foundation. They will become successful as soon as the specific bacterial cause of carcinoma is ascertained. The use of trypsin, amylopsin, pancreatin and other digestive ferments also has not demonstrated results that can stand the test of critical investigation.

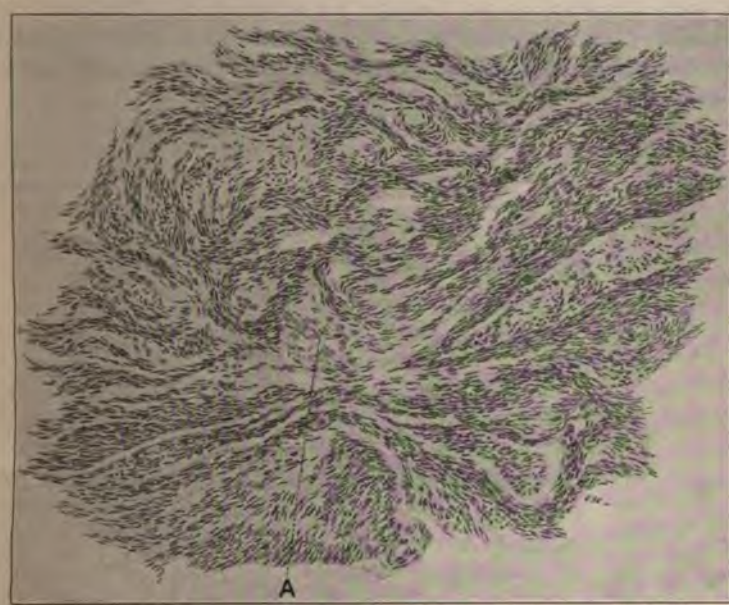


FIG. 174.—Section from the same area of the portio reproduced in Fig. 149 removed July 14, 1914, after 8375 mg. hours of radium element had been applied from April 4 to June 11, 1914. The case was now operable and a panhysterectomy was performed July 14, 1914. The majority of the tissue is of a connective and smooth muscle type. There still remain at *A* a few islands of degenerating or degenerated carcinoma cells. (Author's preparation.)

The application of the roentgen rays, radium and mesothorium has been given a great impetus by the labors of Wickham and Degrais in France, Krönig, Döderlein and Gauss in Germany, the London Radium Institute in Great Britain and Abbe and Kelly in the United States. Actinotherapy is purely palliative in carcinoma of the uterus. As such, however, it ranks first place. The reproduction of the microscopic section in Fig. 174 shows the effect of the radium rays on carcinoma tissue. Compare this section with the one represented in Fig. 149, taken from the same patient before radium treatment was begun.

From April 1, 1914, to October 1, 1919, we treated 165 cases of carcinoma of the uterus with radium rays. For a study of the clinical value of ray therapy we have divided the cases into five groups:

Group 1. Cases which were clearly operable after a physical examination.

Group 2. Cases which were doubtfully operable:

(*a*) Cases subjected to surgery and ray therapy.

(*b*) Cases subjected to ray therapy only.

Group 3. Cases in which an operation was absolutely impossible.

(*a*) Cases subjected to abdominal hysterectomy and ray therapy.

(*b*) Cases subjected to vaginal cautery and ray therapy.

(*c*) Cases subjected only to ray therapy.

Group 4. Cases so far advanced that all treatment was hopeless. They were subjected to ray therapy for purposes of palliation.

Group 5. Cases that recurred after an abdominal panhysterectomy.

The following tables show the total number in each group and the results to date:

TABLE 1.

Group.	Total No.		Living.	Died.	No report or improvement.
1	12		10	2	
2*a*	13	20	7	3	3
2*b*	7		5	2	
3*a*	16	73	2	11	3
3*b*	21		3	8	10
3*c*	36		11	12	13
4	28		1	13[1]	14
5	32		5	11	16
	165		44	62	59

TABLE 2.—TIME ELAPSED SINCE TREATMENT IN LIVING AND DEAD.

Group I.					Group IIa.					Group IIIc.				
Living.		Dead.		No report.	Living.		Dead.		No report.	Living.		Dead.		No report.
yr.	mo.	yr.	mo.		yr.	mo.	yr.	mo.		yr.	mo.	yr.	mo.	
5	2	1	10		4	8	2	..	3	2	..	..	1	
4	9	..	7		2	9	1			1	6	1	2	
3	6				2	6	1	5		1	4			
2	5				1	7				1	2			
4	6					8				1	3			
1	8					9								
1						6								
..	9													
1	3													
1	2													
10		2			7		3		3	5		2		
Total, 12					Total, 13					Total, 7				

[1] Three died within a day or two after the treatment from severe toxemia.

TABLE 3.

Group IIIa.					Group IIIb.					Group IIIc.				
Living.		Dead.		No report.	Living.		Dead.		No report.	Living.		Dead.		No report.
yr.	mo.	yr.	mo.		yr.	mo.	yr.	mo.		yr.	mo.	yr.	mo.	
	6	..	4	3	2	9	1	1	10	2	2	..	7	13
	4	..	2		2	7	..	8		1	2	2	10	
		2	7		2		..	2			10	..	8	
			5				1	6			10	..	2	
			3				..	3			10	1	4	
			5				2	1			8	2	1	
			7				1	8			5	..	8	
			3					6			5	1	3	
		2									4	1	4	
			10								3	..	8	
			8								3	..	10	
													2	
2		11		3	3		8		10	11		12		13
Total, 16					Total, 21					Total, 36				

TABLE 4.

Group IV.					Group V.				
Living.		Dead.		No report.	Living.		Dead.		No report.
yr.	mo.	yr.	mo.		yr.	mo.	yr.	mo.	
4	..	..	4	14	3	3	..	11	16
			2		3	1	..	5	
			1		2	4	..	1	
			5		1	4	1	7	
			5			10	..	8	
			7				1	4	
			2					6	
			2					3	
			2					8	
			0					4	
			5					9	
			0						
			0						
1		13		14	5		11		16
Total, 28					Total, 32				

A study of all the tables demonstrates at once the importance of early diagnosis and treatment. We can hope for improvement in cancer cure statistics only by instituting measures resulting in an earlier recognition and immediate proper treatment of these carcinomata.

The clearly operable cases make a remarkable and favorable showing.

There are 2 deaths in a total number of 12 cases treated. The cases surviving do not show a sign of recurrence at the present writing.

In Group 2, 20 cases were treated. Of these 13 were subjected to operative and ray therapy. Of these 7 are living while 6 either died or did not report. Of the 7 cases treated only with rays 5 are living and 2 died. It is impossible to state whether an operation should have been performed or not as the cases are too few and too recent to permit a conclusion. But it appears to us that surgical eradication does not materially influence the results for the worse.

It is not surprising that Group 3 should give us the largest number of cases, namely, 73. Of these, 16 cases were subjected to hysterectomy either before or after ray therapy was begun or after a local healing was obtained with ray therapy. The results were disastrous. Only 2 patients so far have survived the ordeal. Twenty-one cases were subjected to an initial vaginal cautery before radium was applied. Three patients survive to date, while the average duration of life in those known dead is twelve months. On the other hand 11 of the 37 patients treated only with radium therapy are well at the present writing. The duration of life of those that died in class (*a*) is nine plus months, in class (*b*) twelve minus months, and in class (*c*) twelve plus months. In other words the patients in the latter class had a better chance all around than those in the former. We must conclude that if local healing is obtained the tumor is arrested in growth and the infiltration of the parametria subsides, we should not subject the patient to an unnecessary operation.

Group 4 demonstrates one fact: An advanced cancer patient should be treated only with ray therapy to relieve the symptoms. This is all we can hope for. But little benefit is obtained for the efforts spent.

The intensive intermittent plan of treatment as used in the cases of Group 3 cannot be carried out in this class of cases. The rapid degeneration of tissue invariably causes a severe auto-intoxication. A period of from four to eight days should intervene between applications, that is, until the reaction has subsided.

Group 5 shows a few brilliant therapeutic though temporary results. Recurrent carcinomata are very refractory to radium treatment. Comparing this group with groups 1 and 2 we must state that a combination of surgical treatment and ray therapy shows such favorable results that surgical eradication of carcinomata must always be combined with an intensive ray treatment. If we procrastinate matters and postpone the latter until recurrences appear, and they do appear in about 75 per cent. of the cases within the first two years following the operation, then ray treatment also cannot improve the outlook in the majority of cases. It is our opinion that the sooner after operation the recurrence took place the better the palliation from ray therapy.

If we compare these results with those obtained with the cautery method by the Mayos, Gessner and Gebauer we must draw the con-

clusion that the immediate results are in favor of actinotherapy. The latter method has advantages which the cautery method does not possess namely, the administration of an anesthetic is not necessary, the danger to life is practically nil, the patient is not compelled to remain long in the hospital, and she does not suffer from the pain caused by the cautery. As the technic of the ray treatment becomes perfected, results should show a decided improvement. Indeed we have repeatedly subjected such hopeless cases to laparotomy, buried canals by blunt instruments into the glandular metastases and parametrial infiltrations. The tubes are secured by silk stitches to the parietal peritoneum covering the pelvic structures and to the buttonholes made in the skin. Fifty milligrams of radium element are inserted through these tubes into the periuterine infiltrations and left for twenty-four hours. The applications are repeated twice with an interval of about eight days between the applications. The intestines may be protected by gauze pads which are removed with the rubber tubes on termination of the treatment. Injury to the bowels or ureters may result. However, we do not consider them to contra-indicate our method. For unless the disease is arrested in its progress the patient is doomed.

Pain is a symptom which is rarely absent in advanced cases of carcinoma. The patient complains of a feeling of pressure in the pelvis; paroxysmal, lancinating or gnawing pains in the small of the back, rectum, perineum, lower extremities; dysuria, vesical tenesmus, etc. The pains are combated with acetanilid, antipyrin, aspirin, sodium salicylate, chloral, sulfonal, then pyramidol, heroin and finally codein and morphine. These may be given in the beginning, by the mouth or enclosed in rectal suppositories. Finally, however, we are compelled to administer opiates subcutaneously and in gradually increasing doses. It is advisable to postpone the use of opiates as long as possible because the patient quickly acquires an enormous tolerance. The prescribing of brandy and wines is often beneficial, especially if we encourage the patient to partake of them in such amounts that a stimulating effect ensues. The stench caused from the necrotic cancer masses subsides readily by the filling of the crater with sugar.

As soon as urinary or vesical fistulæ form, the patient's condition becomes intolerable and pitiful. To the indescribable pain and incessant fetid odor of the discharge is now added a urinous or fecal stench. The external genitalia and surrounding skin develop excoriations, which, of course, add to the untold misery. The attendants are practically helpless. We may advise the wearing of a urinal to collect the discharges, order saline rectal enemata to keep the lower bowel empty and clear, resort to potassium permanganate vaginal douches, two tablespoonfuls of a 5 per cent. solution to one liter of water, or insert vaginal tampons saturated with fatty or oily substances, to hold back the involuntary discharges.

If excoriations develop we may advise warm full bath, the applica-

tion of Lassar's paste or zinc ointment to the nates. They are best applied on two pieces of gauze or lint, one to each side.

Recurrent carcinomata require the same methods of treatment as described for primary cases, that is they must be operated, if they can be thus eradicated; otherwise palliative treatment is indicated.

MALIGNANT CHORIONEPITHELIOMA.

A malignant chorionepithelioma is a tumor originating from the epithelium of the chorionic villi, the remnants of a preceding pregnancy, especially a hydatid mole. It is very malignant.

Sänger described such a growth in 1889 terming it a decidua sarcoma. Marchand by his elaborate researches gave it the proper place in oncology and also the present nomenclature of malignant chorion-epithelioma.

FIG. 175.—Chorionepithelioma malignum at the fundus uteri, a portion of the posterior uterine wall removed. (Gottschalk.)

Pathology.—The epithelium of the chorionic villi consists of two layers. The outer is the syncytium, the inner the Langhan's layer. Both proliferate in this neoplasm and one or the other cell elements may predominate. The syncytial portion may occasionally be missing. The tumor always contains blood, either liquid or coagulated. Spindle cells are frequently found especially in the connective tissue surrounding the epithelial cell elements. They also are derived from the chorion-epithelium but change their epithelial character when they invade the connective tissue (see Fig. 176).

The tumor usually grows from the endometrium toward the perimetrium. It is very malignant, of a reddish color, disintegrates early, is very vascular and poor in connective tissue. The surface is villous, the consistency soft (see Fig. 175).

Metastases form very early by way of the bloodvessels. The lungs are the most usual location for them. The primary tumor may have disappeared entirely and yet metastases take place. The tumor grows very rapidly and causes an early cachexia.

Symptoms.—The cardinal symptoms are hemorrhage, discharge and pain, following the termination of a pregnancy. Soon constitutional symptoms appear, chiefly cachexia and symptoms due to secondary invasion of other organs, especially the lungs.

FIG. 176.—Microscopic section of a chorionepithelioma malignum. (A. Martin.)

Diagnosis.—The diagnosis is based on the recurrence of a "placental polypus." The objective findings show a large, soft uterus and reveal, on exploration of the uterine cavity the presence of a villous soft tumor which bleeds easily and profusely. Microscopic examination of expelled tumor débris enables a correct interpretation of the underlying pathology.

Prognosis.—The prognosis is absolutely bad due to the early formation of metastases in other organs.

Treatment.—The treatment is the same as that for carcinoma of the uterus.

SARCOMA UTERI.

The ratio of the number of carcinomata to sarcomata is, according to Gessner, about forty to one. Sarcomata most frequently occur during the climacteric age of women, though no age is exempt.

We distinguish two variaties of uterine sarcomata, (1) the mucous membrane sarcoma and (2) the wall sarcoma of either the cervix or the corpus. The former occurs oftener than the wall sarcoma. The body and collum are involved with about the same frequency.

Pathology.—Endometrium sarcomata are usually composed of
and rarely of spindle cells. They are either circumscribed when
ring in the fundus, or diffuse when invading the entire endomet
They form polypoid tumors which rapidly disintegrate. Hemorr

FIG. 177.—Mucous membrane sarcoma of the uterus. Large round-celled sa
Intact epithelium in places. (A. Martin.)

FIG. 178.—Sarcomatous degeneration of a myoma uteri. (A. Martin.)

extravasations into the tumor mass are numerous. The surface epithelium and glands resist the invasion of the tumor for a long time, but become finally involved. In the last stages all the tissues of the uterus are invaded (see Fig. 177).

Cervical mucosa sarcomata are very rare and mostly spindle-celled. The tendency to polypoid formations is much more marked in the cervical than in the corporeal sarcomata and numerous pedunculated, grape-like masses protrude into the vaginal canal.

2. The pathology of the sarcomata of the myometrium and myocervix is the same. They occur mostly in myomata. Four per cent. of myomata become sarcomatous. The degeneration begins in the connective tissue of the tumors. The latter rapidly increase in size and disintegrate early. Necrosis, hemorrhages and infections are caused thereby (see Fig. 178).

Metastases spread through the blood stream and involve distant organs. Sarcomata mostly occur during the fifth or sixth decades, but no age is exempt.

Symptoms.—It is often very difficult and clinically unnecessary to separate the symptom pictures of a mucous membrane sarcoma from that of a wall sarcoma. The symptoms, common to both, are hemorrhage, discharge and pain and an early cachexia and anemia. The hemorrhage occurs in connection with menstruation, but as the disease advances, may appear at irregular intervals. It is usually very profuse. The intervals between the hemorrhages are characterized by a profuse serous, light red discharge of a fetid odor. The pain is intermittent caused by the efforts of the uterus to expel the contents by contraction of its walls. As the tumor enlarges, pressure pains appear interfering with the functions of the bladder and rectum. A rapid increase in size of a uterine myoma with an exacerbation of the hemorrhages and pain always indicates the appearance of a degeneration of the tumor. The occurrence of cachexia and pronounced anemia, even in the absence of uterine hemorrhages, should lead us to suspect a malignancy. The symptoms referable to this cachexia and anemia are excessive vomiting, headache, insomnia, etc. The respective organs not showing any diseased derangements.

Diagnosis.—The diagnosis of uterine sarcomata is very difficult, unless the tumor is expelled from the organ into the vagina, when it may be readily seen. Palpation may disclose the presence of a villous growth in the cervical or uterine cavity. The history of the case and a microscopic examination will corroborate the diagnosis. Should the sarcoma be intramural then we must consider the history of the case, the symptoms, especially the occurrence of a marked cachexia and anemia, together with the rapid increase in the size of the tumor and a marked change to a soft consistency.

Prognosis.—The prognosis is grave. It may be improved by an early diagnosis, and the institution of a proper treatment.

Treatment.—The principles of treatment for sarcomata of the uterus are the same as those for carcinomata of the same organ.

LABORATORY AND CLINICAL DIAGNOSIS OF FIBROID TUMORS OF THE UTERUS AND THEIR TREATMENT.

By FRANKLIN H. MARTIN, M.D., F.A.C.S., C.M.G.

The diagnosis of fibroid tumors of the uterus is made dependent, in the final analysis, upon all the methods of diagnostic refinement which modern medicine has at its command. Although the recognition of these tumors is rendered easy, in the ordinary case, by a careful palpation of the pelvic organs, it becomes difficult under a great variety of circumstances which supervene only too frequently. These will be taken up *seriatim* with the consideration of the differential diagnosis and of the complications arising. At the outset it were better to regard the diagnosis from the clinical point of view, that is, symptomatically, and to consider the patient as presenting a fairly typical case. The symptoms will then be classified into the two usual groups, subjective and objective.

Subjective Symptoms.—Under the subjective group of symptoms it is always of interest, and of first importance, to inquire into the history of the case. The patient is oftenest in the fourth decade of life when she seeks relief. According to Gusserow no indubitable cases are on record wherein fibroid tumors have been detected or have grown considerably before puberty or after the occurrence of the climacteric. In various statistical series the attempt has been made to show that, within these limits, certain ages are especially disposed toward the development of these tumors. These are unsatisfactory for the reason that collections of medical observations are useless unless accompanied by pathological research which shall furnish at the same time approximate estimates as to the frequency with which such neoplasms are met with in all autopsies held on females. Nevertheless, statistics are of value in giving concrete expression to the sum of many observations.

Lewers believes that uterine fibromyomata only begin to grow between the ages of fifteen and forty-five years. It has been observed by Hauser that while tumors are rarely, if ever, found in girls before puberty, yet those who menstruate early readily acquire fibroids. In this same type the menopause is later than usual, yet fertility is lessened.

Winckel's collection of 528 cases remains authoritative. This shows myomata to occur as follows:

	Cases.
Under 20 years	9
Between 20 and 30 years	98
" 30 and 40 "	180
" 40 and 50 "	180
" 50 and 60 "	52
" 60 and 70 "	6
Over 70 "	2

Gusserow's tabulation of 953 cases from nine sources shows an even higher percentage of cases occurring during the third and fourth decades of life:

	Cases.
10, 14, 16 and 17 years	1 each
18 "	3
19 "	8
Between 20 and 30 "	156
" 30 and 40 "	357
" 40 and 50 "	338
" 50 and 60 "	36
" 60 and 70 "	12
Over 70 "	5

Seven hundred and ninety-eight cases were collected by Schröder, over half of which were found during the fourth decade:

		Per cent.
19 years	2	0.25
Between 20 and 30 "	58	7.26
" 30 and 40 "	229	28.69
" 40 and 50 "	407	51.00
" 50 and 60 "	94	11.77
" 60 and 66 "	8	1.00

Seventy per cent. of the patients observed by Mayer and Schneider were from forty to fifty-five years of age. A comparison of the statistics of these older clinicians with a more modern review of the subject is exceptionally interesting in showing that the former compilations still may be held authoritative. Thus a late study of 700 cases by Ellice McDonald results in almost identical percentages:

		Per cent.
Between 20 and 30 years	19	2.7
" 30 and 40 "	233	33.3
" 40 and 50 "	332	47.2
" 50 and 60 "	95	13.0
" 60 and 70 "	21	3.0

Frequency.—As to the frequency of fibroid tumors in general, there always has been a wide divergence of opinion, due to statistical variation. Thus Monat found that 2 per cent. of all the women in the Hôpital Salpêtrière were so affected and Richard found but 7 cases in 800 autopsies. On the other hand Polloch reported 39 tumors in 800 cases of uterine disease and Kolb claimed that 40 per cent. of all women over fifty years of age are subject to them. The social factors

present rather interesting features. Thus, out of Routh's 301 cases of uterine myomata, 241, or 80 per cent., were married. From other factors entering into consideration Routh estimates that fibroids occur 4.4 times as often in married as in single women.

Gusserow tabulated 959 cases from the reports of nine observers. Of these 672 were married, 287 were single. Of the married women, 464 had borne children, 208 were sterile. Winchel found that fibroids occurred almost twice as often in the married as in the unmarried. Of 555 cases, 140 were single and childless (24.2 per cent.), and 415 were married (75.8 per cent.). Of the latter, 134 were sterile (24.3 per cent.).

That uterine myomata vary in frequency in direct relation to the social standing is the contention of Theilhaber. He finds that they occur much oftener in the wives of financiers, commercial men, manufacturers, high officials, etc., just as carcinoma is more frequently found in the wives of butchers and restaurant-keepers, *i. e.*, in women of the poorer classes. Thus, in Theilhaber's opinion, child-bearing is of little or no importance etiologically, but chronic congestive disorders of the pelvic organs, such as are found most often in women of the better classes, present the active factors.

Heredity does not appear to be a factor of importance in the development of uterine myomata. While cases are observed where these tumors are present in sisters, or in mother and daughters, yet such experiences are so uncommon as to warrant the idea that heredity plays no role or an unimportant one.

Race, likewise, has not impressed clinicians as being a factor of much importance, especially in Europe. There is a strong feeling in this country that fibroids occur much more frequently in the negro race, and some statistical evidence has been produced in support of this idea. The majority of authors, however, do not accept the racial factor as of diagnostic value.

The Factor of Internal Secretions—From the foregoing statistics, however, it is definitely evident that the appearance of myofibromata of the uterus is limited to the years of sexual activity. From this the argument naturally arises that those factors which determine the physiology of the reproductive organs are active in the origin of the growths. This inevitably brings into discussion the importance of the internal secretion of the ovary as well as the responding activation in the uterus. According to Rabinowitz the etiological factor in the development of myomata lies probably in a perverted ovarian secretion, a "myohormone," as is shown by the relative sterility of multiparæ and by primary sterility. This is expressed also in celibates, in whom the sex energy, while still active, finds abnormal expression in tumor development. Thus is explained their appearance most frequently from the thirty-fifth to the forty-fifth years of life.

Mayer and Schneider have applied the principles of Abderhalden's dialysis methods to this question of the relation of fibroid development to the ovarian secretion in an effort to ascertain whether anatomical

changes in the ovary, such as cystic degeneration, angiodystrophy, and increased thickening, were associated with disturbances in its function. The results of this test showed that, as a rule, patients with uterine myomata have ovarian disfunction and that there are active ferments in the serum and substance capable of being catabolized in the ovary which are extraordinarily specific. The conclusion is that this disturbance in ovarian function is primary and that it is the cause of the fibroids.

Reasoning along the same line De Jong has found that the interstitial gland in the ovary is variable in patients in whom uterine fibroma exist. This is true with respect to the number of atretic follicles and the presence of the corpora lutea of menstruation. The corpora lutea may be single, or double, or altogether lacking, these differences bearing no relation to age. There is no reason to assume that the presence of two corpora lutea is due to the presence, or development, of a uterine fibroma, as Pillet suggests, since in 6 of De Jong's cases there were no corpora lutea at all. There is no doubt that the ovary plays a part in uterine hemorrhage in fibroids, as will be emphasized later. Cases of cure by oöphorectomy years ago prove this. But in De Jong's observations the menses were irregular when one or two corpora lutea were present, and irregular where there was none. Hence, all that can be said, in the light of our present knowledge of the ductless gland influence, is that the ovary possesses a regulating action, equally true whether fibroids exist or not.

Developmental Defects.—Another etiological factor of passing interest, at least, is that of Freund who suggested that defective development of the genitalia is responsible for the growth of myomata. He considers that not only adenomyomata but ordinary myomata may, to a demonstrable extent, arise from epithelial rests. The epithelial elements subsequently disappear as a result of the growth and pressure of the tumor. Imperfectly developed uteri and the double uterus especially are more prone to this change and to the origin of tumors in general. General constitutional anomalies, especially infantilism, are also predisposing factors. Benthin, however, finds that Freund's theory is not in accord with his own observations. In 912 uterine myomata he saw but 2 cases of developmental defect, both of which were bipartate in type. On the other hand there were 22 other uterine deformities without fibroid growths. The diagnosis of uterine myomata is further based upon their symptoms.

By way of explaining the symptoms and the objective findings it were better first to consider the varieties of fibroids and their pathology —in other words, the laboratory diagnosis.

Varieties.—The myoma is the commonest newgrowth affecting the uterus. It is believed to take its origin as a proliferation of the muscular and fibrous coats of the smallest arteries. In the "seedling" this small artery may be seen in its center. Since these arteries exist only in the muscular wall of the uterus and never enter the peritoneal or mucous coats, the growths are always, in the first instance, inter-

stitial. From this point of origin they grow either centripetally or centrifugally. In studying the vascular supply of the uterine muscle by means of injected specimens, Keiffer succeeded in demonstrating small bloodless areas which seemed to increase in size at the expense of the surrounding muscular fibers. Around the minute myomata were zones of vascular tissue, evidently an arrangement for the purpose of providing nourishment. Those myomata growing centripetally appeared later to take a horizontal direction. In some instances they remain interstitial but, as a result of the contraction of the muscle layers and the separation of the intermuscular connective tissue, they come to be gradually extruded toward the uterine cavity or toward the uterine periphery. As a result three definite varieties of fibroids are developed: (1) Interstitial, (2) submucous, (3) subperi-

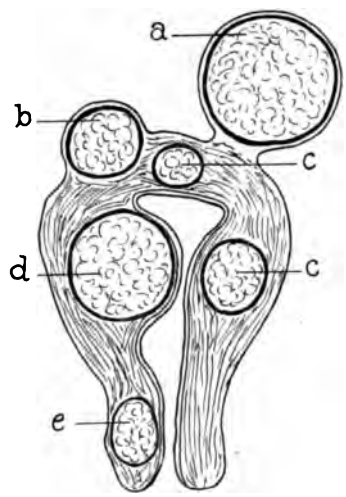


FIG. 179.—Diagrammatic representation of the various types of fibroid growths. *a*, subserous pedunculated; *b*, subserous sessile; *c*, interstitial; *d*, submucous; *e*, cervical. (After Stevens.)

toneal or subserous. Either of these last two varieties may be so far extruded as to become pedunculated. In the submucous variety this permits the tumor to hang suspended, in greater or less degree, in the uterine cavity, producing the so-called *fibroid polyp*, a fourth variety according to some authors. The distinction between these varieties may be quite arbitrary but it is an extremely useful and generally accepted classification. Sampson has suggested that the subserous and submucous varieties be divided in turn, into three groups: (*a*) Embedded; (*b*) sessile; (*c*) pedunculated, and that the subserous include the intraligamentous and retroperitoneal tumors. He also offers a topographical grouping, according to the main arterial supply: (1) Peripheral, those tumors nourished by peripheral branches of the arcuate artery; (2) radial, those tumors nourished by the radial branches of the arcuate artery.

While these tumors are often single, in the greater proportion of cases they are multiple. This arrangement gives rise to another classification, that of: (1) Single, or uninodular, also called simple;

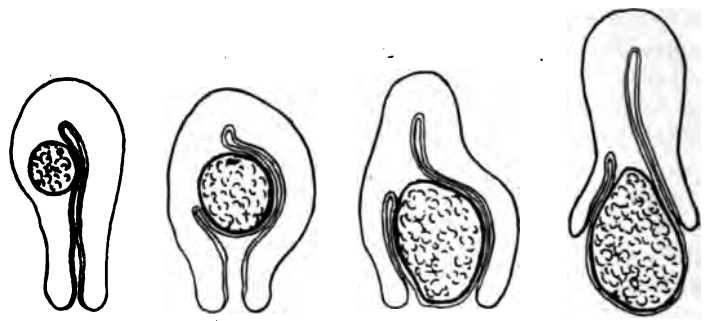


FIG. 180.—Diagrammatic representation showing the method by which a submucous fibroid gradually becomes pedunculated and extended. (After Stevens.)

and (2) multiple, or multinodular, also called compound. Where one specimen shows two or more of these varieties, as is frequently the case, the term, conglomerate, is applied. A further classification

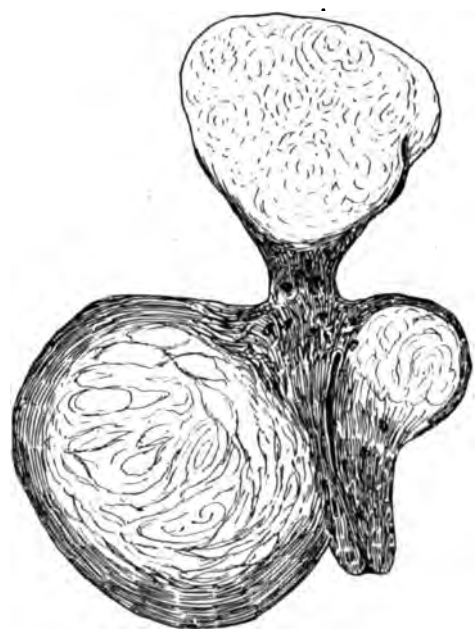


FIG. 181.—Multiple fibroids, one subserous, two interstitial, without involving the mucous membrane or distorting the uterine cavity. (After Winter.)

is based upon the anatomical division of the uterus, *i. e.*, (1) corporeal and (2) cervical. By far the greater majority of fibroids are found in the corpus, the cervical variety being extremely rare.

Finally myomata are classified as (1) discrete or (2) diffuse. The discrete is the encapsulated tumor. The diffuse is usually of a definite variety which will be described under the term, adenomyoma.

As to the relative frequency of these varieties, McDonald's series of 700 cases offers interesting statistics:

		Per cent.
Single	238	34.0
Multiple	462	66.0
Small	257	36.7
Medium (4 cm. in diameter)	209	29.8
Large (4 to 8 cm. diameter)	234	33.5
Subserous (over 8 cm. diameter)	136	19.5
Interstitial	190	27.1
Submucous	75	10.7
Combined	299	42.7

Of Schorler's series, 27 were cervical and 307 corporeal. Of the latter, 106 were interstitial, 128 subserous, 24 submucous and 49 polypoid.

Winckel reported one series of 90 cases, 39 of which were pedunculated. In another series of 230 cases, 130 were interstitial, 74 subserous, and 26 submucous. Of 60 cases compiled by Jacubasch, 58 were in the corpus, 22 of which were submucous, and but 2 in the cervix.

THE NATURE OF FIBROID TUMORS.

The growth of the fibroid takes place equally on all sides and in a straight line. As a result it is spherical and symmetrical. If unsymmetrical this is due to contractility of the uterine musculature rather than to the resistance of neighboring parts. The typical tumor consists of tissue identical with that of the uterus, that is, involuntary muscle fibers and fibrous connective tissue. In the myoma the smooth muscle bundles are in excess, with but a small proportion of connective tissue, the whole being surrounded by the fibrous capsule in which ramify the bloodvessels leading to the tumor. In consistency it is not harder than the wall of a normal non-pregnant uterus. The fibroma is made up chiefly of connective tissue, with relatively less of the musculature, and is very dense and hard. On section it shows a whorled appearance due to the fact that the various bundles into which the fibers are arranged run in different planes. In the center of each whorl is a bloodvessel and the capsule is identical with that of the myoma. According to Keiffer the fibromyoma probably represents a localized hypertrophy of the tissues in the neighborhood of certain vessels, or the isolation of vascular areas due to thrombosis, prolonged pressure, or other circulatory disturbances.

The capsule is typically characteristic only in the interstitial variety, whereas a subserous fibroid, extruded beneath the uterine peritoneum, becomes almost completely invested with the serous coat and its connection with the uterus may take on the form of a narrow stalk or pedicle through which its nutrient vessels pass. Or a fibroid growing from the side of the uterus may force its way between the folds of the

broad ligament without taking on an intimate peritoneal coat. Some of these show little or no attachment with the uterine wall and some have a narrow pedicle resembling a tendon. Likewise, tumors developing near the uterine cavity and extruded beneath the mucous membrane tend to lose the capsule and become invested with mucosa only. Here again pedicles form, and, in the shape and disposition of the uterus, effects similar to those of pregnancy are produced. The histology of the myoma is best brought out by von Giesen's stain. This reveals clearly the difference between the connective tissue and the muscle fiber, and the proportion of the one to the other. This proportion varies very considerably in different fibroids. The interlacing bundles of muscle cells and fibrous tissue are seen arranged somewhat more compactly than in the unaltered uterine wall, while both cells and nuclei show marked elongation. Some tumors are much more richly cellular than others, a point which explains the difficulty at times experienced in differentiating them histologically from sarcomata.

Latent Fibroids.—Minute tumors are occasionally found in the wall of the uterus upon autopsy or after its removal by operation. These may exist singly or in large numbers without distorting the uterus or producing either symptoms or local findings. They may remain latent for years and never be recognized, but at any time, without apparent cause, they may develop into troublesome tumors. Practically they are important in the bearing they have toward fibroid recurrence after myomectomy. Not so rarely, where a subserous or submucous tumor has been enucleated, the patient returns in a few years with another myoma which has developed from one of these so-called "seedlings." Hence there is developed this important factor in the method of operation with respect to the surgical treatment of the fibroid uterus.

Broad Ligament Fibroids.—In the loose connective tissue of the broad ligament are found these tumors identical in structure with uterine fibroids. They are round or oval, encapsulated, and unilateral or bilateral. They cause little or no trouble until large enough to produce pressure in the pelvis and sometimes they may reach a great size, growing upward into the abdomen. As a rule, they cannot be differentiated from the subserous variety until the abdomen is opened. When bilateral they tend to bulge posteriorly, thus displacing the uterus forward and eventually downward. Bland-Sutton has reported one such tumor that weighed thirty pounds. When large they are particularly subject to degeneration.

Round Ligament Fibroids.—These arise not only in that portion of the ligament which lies between the layers of the mesometrium but also in the region of the inguinal canal. They have been described as desmoid tumors and as sarcomata but they show the same structure as intramural or subperitoneal uterine fibroids. They may appear singly or in association with tumors in the uterus and rarely grow larger than 5 or 6 cm. in diameter.

Fibroids may also appear in the uterosacral ligaments. Here they grow to the diameter of 1 or 2 inches, taking on a flattened shape and being attached to the side of the uterus by a tendon-like pedicle. They are the rarest of all the extra-uterine fibroids.

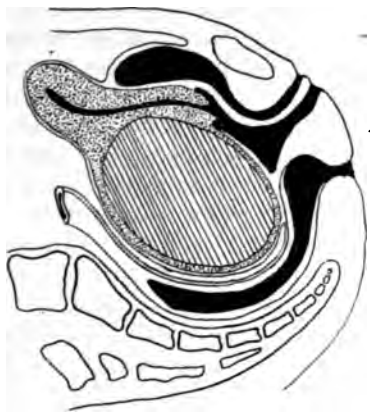


FIG. 182.—Diagram of a fibroid in the posterior cervical wall growing between the rectum and the vaginal wall. (After Stevens.)

Fibroids of the Cervix.—This tumor is usually solitary but it may be associated with fibroids in the corpus. In structure it is the same as other fibroids and is subject to the same degenerations and is perhaps somewhat more liable to infection. It differs from other fibroids chiefly in its relations to the bladder, ureters and rectum. Large

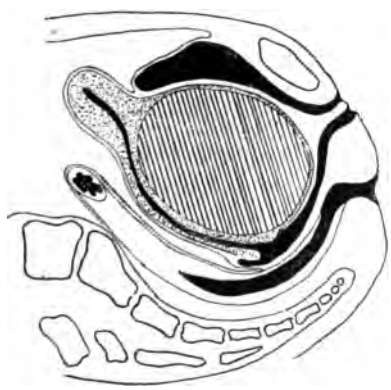


FIG. 183.—Diagram of a fibroid in the anterior cervical wall growing between the bladder and the vaginal wall. (After Stevens.)

myomata of the posterior cervical wall lead to obliteration of the posterior lip and to typical displacement of the uterine artery outward and of the bladder and corpus upward. The ureters are usually displaced out and downward, upward only if the tumor grows beneath

the ureters into the parametrium. It is obvious that as soon as a cervical fibroid becomes sufficiently large to block the pelvic outlet it will press injuriously against the urethra. The growth is so insidious that often the first symptom of its presence is urinary retention, due either to direct pressure on the urethra or to the bladder being drawn up as the uterus is pushed into the abdomen. This pressure, by displacing and disorganizing the bladder, urethra and ureters, as well as the renal pelves, produces thickening or dilatation of the structures which adds greatly to the risk of surgical treatment. When multiple fibroids, separate from each other, are present these displacements are all the more complicated. The sigmoid flexure will be pushed upward and the rectum pressed back into the pelvic concavity, with resultant obstructive constipation. Combined internal and external examination may suffice to determine these relations, but oftener it is necessary to inspect carefully, after the abdomen is opened, before proceeding with the operation.

Since the mucosa of the cervical canal does not take part in menstruation, cervical fibroids are not associated with menstrual disturbances. Fibroids in the cervical canal, however, especially if pedunculated or combined with polyps of the mucous membrane, are apt to produce irregular hemorrhage by becoming infected and then breaking down. Such bleeding is in the nature of cervical hemorrhage due to the opening up of bloodvessels and not that characteristic of menorrhagia. When a cervical fibroid is associated with corporeal tumors, excessive menstrual bleeding, of course, may be present.

Adenomyoma of the Uterus.—This condition, while pathologically distinct from myoma, is so closely related to it clinically and in gross appearance that it must be considered briefly in the same connection. It was described by von Recklinghausen some years ago and more recently shown to be a definite pathological entity by Cullen in his very elaborate monograph. It represents an overgrowth of the epithelium of the corpus uteri together with an increase of the connective tissue in which the glands are implanted. It has not been settled whether this growth is due to microörganic action, the result of chronic septic infection, as is contended by some English and most German writers, or whether it is a true tumor, the result of changes occurring in the Müllerian ducts in the embryo. For a discussion of this problem the reader is referred to Cullen's work.

This adenomyomatous change may involve the entire endometrium, thus producing a uniform thickening of the walls of the uterus, but more often it is limited to a portion only of the wall. Its striking characteristic, grossly, lies in the fact that it possesses no capsule, the term, "diffuse," being very aptly applied. On cross-section the whorl-like arrangement is absent but the cut surface shows small open spaces, sometimes resembling an irregular, widely separated network. Microscopic examination shows that this growth consists mainly of unstriped muscle fibers arranged irregularly and inclosing spaces containing the embryonic interstitial connective tissue characteristic of

the uterine mucosa with gland tubules like those of the same structure, lined with identical columnar epithelium. Indeed the glandular elements are in every respect identical with those of the mucous membrane of the uterine corpus. This has been proved both by injection processes and by serial sections, demonstrating a definite continuity with the normal endometrium. These glandular spaces are unevenly distributed and vary considerably in amount in different specimens. The glandular material may become so profuse as to project into the uterine cavity in polypoid formation, and frequently the tubules become dilated, or slightly cystic. The resemblance of this growth to carcinoma is occasionally emphasized by the appearance of a double row of epithelium, resembling the so-called malignant adenoma. Bland-Sutton denies, however, that this condition is malignant.

FIG. 184.—Adenomyoma uteri. The section shows groups of endometrial glands, some cystic, diffusely scattered throughout tumor and uterine wall. The stroma in which they lie corresponds to the interstitial type of connective tissue (embryonic) of the normal endometrium. (After Lewers.)

These glandular spaces are further interesting in that they pass through all of the phases of the menstrual reaction. The interstitial tissues take on the characteristic menstrual edema and hemorrhage, a fact which explains periodic increase in the size of the tumor, tubular dilatation, and the presence in the fresh specimen, at times, of thick, tar-like, retained menstrual blood. The possibility of pregnancy occurring within such a tumor is therefore suggested, and, indeed, one such case has been reported by Doederlein and Herzog.

While never extremely large, adenomyomata usually cause an increase in the size of the uterus. Cases are on record where the uterus has measured as much as 30 cm. in diameter and where the fundus has risen high in the hypogastrium.

Ectopic Adenomyomata.—The fact that an adenomyomatous condition may exist beyond the uterus has but recently been recognized. Stevens has published the report of 6 cases of adenomyoma of the recto-vaginal septum and similar cases are recorded by Cullen and by Mayer. These growths are of interest here only because of their close proximity to the uterus and their importance in differential diagnosis. Usually they are recognized only in the laboratory. In structure they are in all respects similar to adenomyoma of the uterus, being made up of corporeal muscle and mucous tissues and subject to the same changes. Indeed, one of Stevens's cases involved the posterior uterine wall. The growths involve the wall of the rectum, as a rule, but leave the rectal mucosa intact, so that there is no rectal hemorrhage. The German writers regard them as developing, again, from a

FIG. 185.—Submucous fibroid producing distortion of the uterine cavity, with a subserous growth producing asymmetry. (After Kelly.)

basis of chronic inflammation, but Cullen and Stevens both regard them as true tumors, originating in misplaced Müllerian tissue. These tumors have also been described in the round ligament, in the inguinal canal, and in the scar of an abdominal wound where operation for ventrofixation of the uterus had been performed.

Changes in the Uterus.—Of the changes which occur in the uterus in the presence of uterine myomata it should be noted that there take place a general muscular hypertrophy, most marked in the interstitial and submucous varieties. The cavity becomes increased in size, varying greatly according to the size and disposition of the tumors, dilated in some instances, or very tortuous where one or more sub-mucous fibroids press into it. The endometrium may remain relatively normal but often it undergoes a considerable increase in thickness, at times closely resembling, in gross appearance, the decidual char-

of pregnancy. This is usually referred to by most authors as an interstitial and glandular hypertrophy and Bland-Sutton refers to it repeatedly as an edema. In the majority of cases, however, this thickening is a true hyperplasia, appearing microscopically as a diffuse adenoma. It is true that many glands are enlarged but this is due rather to retention dilatation than to organic hypertrophy. This change in the mucosa is not characteristic of fibroids alone, since it is also seen sometimes in chronic metritis and in that rare condition of the uterus known as *fibrosis uteri.* In the submucous variety of fibroids the mucosa covering the tumor is usually atrophic, the degree of atrophy depending upon the pressure exerted upon it by the underlying growth. The rest of the mucous membrane may be normal or hyperplastic. Where the underlying tumor has grown

FIG. 186.—Small intramural fibroids, with diffuse hyperplasia of the corpus mucosa. (After Bland-Sutton.)

rapidly or where pressure has become excessive, the mucosa becomes very thin or may give way entirely thus permitting the fibroid to be extruded into the uterine cavity without covering. The same result may follow infection and ulceration of the mucous membrane, in which case the tumor will become infected and may even slough out.

Effect on Adjacent Structures.—The Fallopian tubes are often affected secondarily in the presence of fibroids of the uterus. They become adherent and displaced. The adhesions frequently fix the tubes to the lateral pelvic walls, or to the broad ligaments and ovaries. These adhesions are rarely dense or organized, unless septic infection has coexisted, but more often they take the form of delicate bands characteristic merely of serous irritation. The fimbriæ in this way often become occluded with resultant hydrosalpinx formation, though occasionally the distended tubes will contain not only serum but blood

as well. Pyosalpinx will be found only where septic infection has occurred.

The ovaries are, as a rule, enlarged and hypertrophic, frequently presenting the condition known as fibrocystic degeneration. They, too, become adherent and displaced. The adhesions are of the same variety as those involving the tubes. The ovary is perhaps oftenest adherent to the broad ligament posteriorly, but when it is elevated high in the pelvis or into the abdomen it becomes fixed to any adjacent structure. As a result of pressure in large or impacted tumors the ovary is flattened and thinned out against the pelvic wall, and rarely the pressure exerted is so great that it disappears as a gross structure.

The uterine ligaments become hypertrophic and elongated or attenuated and stretched. As a result of the greatly increased blood-supply required the bloodvessels are immensely enlarged. The arteries increase enormously in size, giving off numerous branches, and the veins are distended and varicosed. Many adventitious vessels are formed where adhesions have become dense and well organized.

Adhesions between the fibroid and the peritoneum are produced as a result of pressure and friction. As a rule, these are light and cobweb-like in nature and stretch so readily that mobility is not impaired nor pain provoked. On the other hand adhesions may become extensive and dense, producing fixation of the tumor and its attachments or uniting various portions of the abdominal viscera with it. Thus, large abdominal tumors have been found where the entire lateral and anterior peritoneal walls have been fixed densely, with the omentum and intestines free. Again, various loops of ileum or colon may be adherent when the parietal peritoneum remains unattached. Occasionally the omentum will be found united throughout a greater or lesser extent. In this latter circumstance particularly is bloodvessel anastomosis is apt to occur. It is when intestinal complications ensue that septic infection is most apt to occur. No abdominal condition is more serious than a large uterine fibroid with septic peritonitis.

Large movable tumors by irritating the peritoneum result in a free serous transudate. This ascites is rarely considerable enough to be recognized clinically. It has been found also where a pedunculated tumor has rotated on its axis.

The urinary bladder is discommoded in greater or lesser degree. Fibroids in the cervix more often produce retention, those of the anterior wall irritability. Where the bladder is drawn up into the abdomen by large growths, urinary frequency is again the rule. Pressure on the ureters, as occurs where pelvic tumors become impacted, results in ureteral dilatation and hydronephrosis, pyelitis ensuing with infection.

The influence of uterine myomata on the rectum most frequently results in constipation. Occasionally there may be a temporary period of diarrhea, as if the colon were subjected to irritation, but obstruction of the rectum or sigmoid flexure as a result of direct

pressure is much more common. Where pelvic impaction has occurred hemorrhoids form, associated at times with varices and edema of the labia. Owing to the slow growth of the tumor and the gradual development of adhesions, intestinal obstruction is extremely rare. Likewise very few tumors, even giant ones, seriously impede the activity of the stomach. Fatty degeneration of the liver has been noted in some instances but the probability of this change being due directly to the fibroid is problematical. More often liver changes are discovered at autopsy.

Cardiovascular Changes in Fibroids.—The relation between uterine myomata and heart disease has long been a subject for debate. It must be acknowledged that it is not always easy to arrive at a positive and accurate diagnosis of heart lesions and to estimate the relation they bear to fibroid tumors. For this reason autopsy reports are of definite value in a study of this relation. McGlinn found organic lesions of the heart 241 times in association with 100 fibroids of the uterus and 232 times in 100 autopsies where fibroids were absent. McDonald's statistics show cardiac lesions to be present in 11.5 per cent. of his fibroid cases that come to autopsy. According to Mahler the pathologic changes in the heart represent the total result of injury caused by hemorrhages and such ovarian disfunction as may exist. Without doubt functional murmurs of the heart are frequent as a result of excessive bleeding, and to these are added later the symptoms of hypertrophy and dilatation due to abnormal innervation when the tonus of the autonomous and vegetative nervous systems is depressed. While denying that the definite entity of "fibroid heart" can be sustained McGlinn finds associated sclerotic heart changes in women of middle or advanced age with uterine myomata. Large tumors increase the work of the heart and by pressure bring about hypertrophy and dilatation. Hence fatty degeneration, brown atrophy, cloudy swelling and myocarditis appear to be due not to the tumor itself but to the foreign conditions set up by their presence.

Secondary Changes.—That fibroid tumors of the uterus are peculiarly subject to various changes has long been known and their recognition has come to constitute one of the interesting features of this always interesting condition. These changes have an important bearing on the diagnosis, since through them signs and symptoms become modified. Their influence on treatment is even greater, since in their very nature degenerations constitute factors making difficult the practical application of definite therapeutic principles.

These secondary changes may be simple or functional in character. Thus, *atrophy* may occur in small tumors at the menopause, where the growth has never interfered functionally with the uterus or ovaries. The change corresponds with the atrophy of the uterus and for this reason is more apt to occur in true myomata, muscular tissue yielding more readily to senile atrophy than fibrous connective tissue. *Edema* is another simple change, an expression of early inflammatory reaction or of circulatory disturbance. In pedunculated tumors it occurs as

a result of torsion. Here the tumor enlarges rapidly, becomes softer and shows a general serous effusion, lymph spaces being dilated. At times this resembles a cystic degeneration. Edema also occurs functionally in pregnancy and menstruation. The relation of fibromyomata and pregnancy will be discussed more fully in another place, but the influence of menstruation may be mentioned here. The fibroid is affected as is the uterine wall. There is a monthly enlargement which may involve the entire resting and premenstrual stages. Then ensues a shrinking which is usually rapid. The mucosa describes its typical monthly cycle and in cases where hyperplasia exists these changes are exaggerated. Pelvic fibroids become temporarily impacted during menstruation, with resultant emphasis of pressure symptoms.

The more important secondary changes may be classified as follows:

1. Benign degenerations: (*a*) Fatty, (*b*) myxomatous, (*c*) hyaline, (*d*) calcareous, (*e*) cystic, (*f*) hemorrhagic, (*g*) necrotic.

2. Malignant changes: (*a*) Sarcomatous, (*b*) carcinomatous.

According to Messa, 30 per cent. of all uterine fibroids show degenerative processes. Of 100 cases reported by Cullingworth, 52 were degenerated. No more interesting statistics showing the frequency of these degenerations have been produced than McDonald's in his recent report on 700 cases. A brief resumé of his findings will be of value. Hyaline degeneration occurred in 18 per cent., calcareous in 9, cystic in 3, hemorrhagic in 2 and necrotic in 8 per cent., respectively, or 40 per cent. of his entire series showed cellular degeneration. According to age they occurred as follows:

A. Hyaline degeneration:

	Per cent.
From 20 to 30 years	11.0
" 30 to 40 "	11.5
" 40 to 50 "	16.8
" 50 to 60 "	16.6
" 60 to 70 "	10.0

B. Calcareous degeneration:

	Per cent.
From 20 to 30 years	0.0
" 30 to 40 "	2.0
" 40 to 50 "	16.0
" 50 to 60 "	14.0
" 60 to 70 "	10.0

C. Necrosis:

	Per cent.
From 20 to 30 years	5.0
" 30 to 40 "	7.7
" 40 to 50 "	7.5
" 50 to 60 "	9.3
" 60 to 70 "	29.0

D. Malignant changes:

	Per cent.
Adenocarcinoma	2.9
Squamous carcinoma	0.8
Chorio-epithelioma	0.3
Total	5.0

E. Malignant changes according to age:

	Per cent.
From 20 to 30 years	0.0
" 30 to 40 "	0.0
" 40 to 50 "	5.0
" 50 to 60 "	12.7
" 60 to 70 "	23.8

1. **Benign Degenerations.**—These are true cellular degenerative changes.

(*a*) *Fatty.*—This is a rare change except after pregnancy or the menopause. After pregnancy it constitutes merely a part of the involutionary process involving the whole uterus as it does in senile atrophy after the menopause. Earlier it involves the tumor in part or in whole, destroying the muscle fibers and thus producing a single large cyst, or multiple small cystic spaces.

(*b*) *Myxomatous.*—Mucoid degeneration is one of the commonest changes that occur in fibroids. It is brought about by an alteration in the blood-supply, possibly an increase in the number of bloodvessels with obstruction of return circulation. It begins as a hyaline transformation of fibrous tissue, fibrillation is lost and the stroma gradually liquefies, a process subsequently undergone by the muscle bundles. These drops of fluid coalesce forming cavities which eventually run together into large ragged-walled spaces filled with a jelly-like or fluid material. In this way the "fibrocystic tumor" is formed, a growth so unlike the typical myoma at times that early gynecologists classified it separately. Clinically it is characterized by sudden rapid enlargement with fluctuation.

(*c*) *Hyaline.*—In some instances degenerative processes are limited to a hyaline change of the muscle or connective-tissue cell. As a rule, however, this change is an early one, preceding the further degeneration leading to myxomatous or pseudocystic transformation. Occasionally hyaline change is seen associated with calcareous and necrotic development as well.

(*d*) *Calcareous.*—This, according to de Tarnowsky is the rarest of all degenerations. Of 6496 cases of fibromyomata which he collected from the literature, 182 showed calcification, or 3.5 per cent.; 79 per cent. were interstitial or subserous; 18 per cent. were free in the uterine cavity, forming the so-called "womb-stones." Very rarely they have been found free in the abdominal cavity. For the most part these areas are composed of phosphates and carbonates of lime, Bernardie reporting tribasic calcium phosphate in 90 per cent. of his cases, carbonate of lime in 15 per cent. and sulphate of lime in 0.05 per cent.

Macroscopically they vary somewhat in appearance. In one variety the process begins centrally and is often a shell containing a soft pulpy material which becomes infiltrated with calcareous granulations or it atrophies. After the shell is formed the blood-supply is diminished or lost and the center necessarily undergoes some form of necrobiosis. In a second type small phosphatic granulations take

place, coalescing and spreading peripherally in the neighborhood the fibrous septa along which bloodvessels pass. This process grad ally goes on until a hard white ball is formed. The stroma disappea and cross-section shows a polished surface. More often, howev the spaces between the septa do not calcify but disappear. This giv a porous, worm-eaten appearance to the area. Bernardie has describ a few cases wherein the process has gone on to a true osseous formati characterized by bone cells and a primitive Haversian system.

Histologically there is always at first a stroma of muscle and co nective tissue fibers containing calcified plaques. The muscle ce gradually disappear and are replaced by connective tissue, in which lime salts infiltrate. The bloodvessels become obliterated, a necrobiosis with loss of anatomic detail results. It is most pro able that the phosphoric and fatty acids always present in necr biotic tissues cause a precipitation of the calcium salts in the bloo It has been suggested that the process is identical with that seen chronic gout or arthritis deformans. At all events arterioscleros seems to be essential in its pathogenesis.

Further than this, however, calcification requires aseptic conditio in the fibroid. As de Tarnowsky has shown, if the original fibro becomes infected, with the colon bacillus for instance, further chang other than those due to bacterial infection cannot occur. This m furnish one explanation as to why calcification is so rare.

(*e*) *Cystic.*—The formation of the fibrocystic tumor from the myx matous has been mentioned. Cystic change is also seen in lymp angiectatic growths with enormous distention of the lymph spac forming large cavities filled with clear fluid which coagulates wh exposed to air. These cavities are lined with endothelium, wherel they are distinguished from the myxomatous type. A third conditi giving rise to cyst formation is necrosis or necrobiosis without infe tion. This is particularly apt to coexist with fatty or sarcomato change. The contents of the cystic spaces is a thick, opaque materi which may be bloody. Finally, a dilatation of bloodvessels in t tumor rarely takes place, so-called telangiectasis, giving rise to cavernous or cystic formation. The cystic formation that may ta place in adenomyoma has already been referred to. Cystic degener tion may appear suddenly and cause symptoms of acute illness, simil to ovarian cystoma with torsion of the pedicle.

(*f*) *Hemorrhagic.*—Escape of blood frequently takes place in any of these degenerating fibroids, hence it is somewhat beside t mark to speak of hemorrhagic degeneration as a type. Indee tumors not otherwise affected do not show it. Hemorrhage is pa ticularly apt to appear in cases of cystic formation. Thus Gunak reports it as occurring in 74 per cent. of such cases. In the presen of necrosis it is also frequent and in malignancy eventually a consta expression.

(*g*) *Necrosis.* 1. *Necrobiosis.*—This is a frequent secondary chang the result of circulatory disturbances whereby the blood supply i

PLATE VII

Uterine Fibroid Showing "Red Degeneration".

more or less destroyed. It is found oftenest in the interstitial or subserous fibroids and involves usually but a part of the nodule. The position and mode of development of the tumor are perhaps the most important factors in necrosis, though thrombosis of the veins of the capsule is an almost constant finding. Its appearance strongly suggests infarction, but this has not been proved for all cases. It occurs most frequently during the years of reproductive activity, and the frequency of its occurrence during pregnancy has attracted attention. The process begins in the center of the tumor and is essentially an aseptic necrosis. The fibers lose their sharp outlines, gradually becoming softer and fainter until a soft homogeneous mass is the result. This may become very white, due to the loss of the blood-supply, in which case it resembles sarcoma closely. In other cases

FIG. 187.—Section including the capsule about an area of "red degeneration," showing numerous bloodvessels with engorgement or thrombosis. Some round-cell infiltration about the edges.

there is an effusion of blood beneath the capsule as a result of which the degenerate portions appear as red as raw beef, the so-called "red degeneration." At times, too, this red appearance fades, giving various shades of brown. Clinically necrobiosis is marked by menorrhagia or metrorrhagia, leucorrhea, pain in the tumor, fever, leukocytosis and such signs of intoxication as acetonuria, indicanuria, albumin and casts. Thus the ordinary picture of uterine fibroids may be very considerably changed.

Smith and Shaw and Leith Murray have recently given particular attention to red degeneration, and Bland-Sutton made a careful study of 40 specimens, 26 of which were associated with pregnancy. Histologically these red fibroids differ not at all from other forms of necrosis. Murray attributes the change to the action of hemolytic

lipoids and Smith to simple hemoglobin staining associated with the action of the accumulated fat. Thrombosis of capsular vessels is a constant finding. A second variety of red degeneration, the angiomatous, is characterized by a large number of thin-walled vessels filled with red corpuscles. Besides considerable congestion there is free blood in the tissues. This gives a bright red color which soon fades and which is due to blood in the tissues and vessels rather than to hemolysis and hemoglobin staining. Strictly speaking this is not a true necrobiosis but rather a simple angiomatous formation. The tumor is not essentially painful and the other clinical symptoms referred to are absent.

2. *Infection.*—Bacterial invasion from without gives rise to a definitely different form of necrosis. Infection takes place (*a*) by the exposure of a pedunculated tumor in the cervix or vagina with strangulation and injury of the capsule, (*b*) as a result of injury and the entrance of bacteria after menstruation or labor, (*c*) by extension from infected Fallopian tubes, and (*d*) extension of infection from adherent intestine. Ascending vagino-uterine infection is by far the most common and hence the polypoid or submucous tumor is most frequently involved. The result of such infection is suppuration and ulceration of the involved tumors, with gangrene as an end-product. In the subperitoneal fibroid, an abscess will develop which may discharge fortunately into the uterus or rupture disastrously within the abdominal cavity giving rise to general suppurative peritonitis. Sloughing, with extrusion of the tumor has taken place after labor. These infectious processes are due oftenest to the colon bacillus, though the streptococcus, staphylococcus, gonococcus or tubercle bacillus may be the primary agent. Anaërobes may play an important role also. Clinically the condition produces pain in the tumor, disturbance in the general health, fever, leukocytosis and emaciation. It may render an otherwise easy diagnosis very complicated and is particularly apt to be mistaken for incomplete abortion or cancer.

2. **Malignant Changes.** (*a*) *Sarcoma.*—There is discussion from time to time as to whether sarcoma should be considered as a true degeneration or a secondary neoplastic implantation. The majority of writers favor the idea that it probably is a true tissue change, as represented by Virchow, Cullen and others. While difficult to prove, this position represents the best thought today. Owing to the fact that both tumors take their origin from the same kind of cell, it is not always easy to say whether a sarcoma may arise in a fibroid and destroy it or whether a supposed fibroid may not be a sarcoma of low degree of malignancy from the first. Particularly where fibromata are undergoing degeneration is it difficult to distinguish malignant transformation. Nevertheless it is probably true that the great majority of uterine sarcomata are discovered in the presence of fibroid tumors, how frequently may be seen from the following observations: Winter and Ruge found sarcoma present in 2 per cent. of subserous, in 4.5 per cent. of interstitial and in 9 per cent. of submucous fibroids.

Klein studied 491 myomata and observed sarcoma in 2.6 per cent. Mackenrodt observed it in 1.7 per cent. of his cases. Miller's compilation of 9,750 cases from various sources shows an average percentage of 2. As Winter and Ruge have shown, sarcoma appears oftenest in the submucous myoma, taking its origin either in the fibrous connective tissue, myosarcoma, or in the muscle cells, myoma sarcomatodes. In the endometrium it develops as rounded homogeneous masses of cells with little intervening tissue. The tissue cells in which this change takes place show hyperplasia and heteroplasia, varying in size, with large and small cells side by side. The nuclei are large, irregular, stain indifferently and show mitotic figures as well as direct division. Grossly the surface is soft, yellow-white, with an indefinite margin. Small, irregular, yellow areas of necrosis and small points of interstitial hemorrhage may be seen. Cystic areas representing dilated lymph spaces or necrotic foci may occur, together with extension of the tumor along the bloodvessels. While differentiation grossly is difficult, in simple degeneration without sarcomatous change the elements represent fully formed mature tissue. In shape, size, staining properties, etc., the individual types of cells remain uniform.

(*b*) *Carcinoma.*—For the most part all clinicians are agreed today that carcinoma does not appear as a true degenerative process in uterine myomata but is a secondary implantation. Conditions favoring fibroids also favor carcinoma. This is seen in the fact that cancer of the cervix is rare in myomata of the corpus, though it occurs by far most frequently in the cervix. On the other hand, occurring relatively seldom in the corpus in non-fibroid uteri, it appears there apparently three times as often when fibroids exist. The two growths are independent, the carcinoma originating in the endometrium from which point it invades the fibroid. In 500 uteri removed for myomata Bland-Sutton found 8 specimens showing cancer. All of the 8 patients were over fifty years of age. According to Jansen carcinoma of the corpus occurs in 3 per cent. of all myomatous uteri, whereas it is found in but 2 per cent. of the non-myomatous. Of 359 operative cases Olow found cancer in 16, or 4.45 per cent. In Haulstein's experience it appeared in 4.1 per cent. of the cases and in 3.8 per cent. of Martin's. Hertel studied 1100 cases, of which 468 were operated upon. Of these latter there were 29 carcinomata, 16 in the corpus mucosa and 13 invading the musculature, besides 8 others involving the cervix.

Without the microscope early recognition of malignancy in the presence of fibroids may be impossible, as the differentiation of carcinoma from sarcoma is at any time. Where, after mid-life, a known fibroid suddenly grows larger and becomes tender, malignant change must be suspected. If this is accompanied by increased loss of blood, or definite metrorrhagia, and a foul necrotic discharge, the probability is strongly in favor of malignancy. Loss of weight, cachexia and secondary anemia are late symptoms that are never seen in simple

myomata. They always indicate profound septic infection or cancer. The fact that the largest proportion of malignant changes occur in fibroids that are necrotic or cystic renders an understanding of these symptoms peculiarly difficult.

Other Complications of Uterine Myomata.—A few other complications of fibroids require but brief mention. In 1913, Poth collected from the literature 82 cases of torsion of subserous pedunculated tumors and reported one case of his own. Thus, this accident is rare. It is accompanied by a sudden increase in growth of the tumor, with pain and pressure symptoms. Evidences of peritoneal disturbance are present, vomiting and abdominal distention or rigidity, similar to signs of torsion of an ovarian cyst. A serous or hemorrhagic transudate forms in the abdominal cavity. This may result in gangrene.

FIG. 188.—Sessile fibroid with axial rotation, involving the uterus and appendages in the twist. (After Bland-Sutton.)

A few cases have been reported where the pedicle has ruptured, permitting the tumor to lie free in the abdomen.

Rupture of the enlarged tortuous bloodvessels, occurring spontaneously, has been known to take place. Here the signs would be those of internal hemorrhage. Such a case was reported in 1913 by Sadlier. After removal of considerable free blood from the abdominal cavity, multiple fibroids of the uterus were discovered, with a ruptured artery still bleeding at the summit of one lobule.

Other pelvic tumors are frequently found associated with fibroids, as are various inflammatory foci. In his report of 700 cases, McDonald shows that ovarian cystomata occurred 53 times, or 7.5 per cent.; ovarian fibromata 8 times; ovarian carcinomata 5 times. Cystic degeneration of the ovaries was present in 141 of these cases, or 20 per

cent. The frequency of hydrosalpinx has been referred to. Pyosalpingitis is also found in many cases, forming, indeed, a common factor in differential diagnosis. McDonald reports salpingitis as present 194 times, or 27.5 per cent., in his series, and appendicitis 148 times, 21 per cent.

The Relation of Fibroids to Fertility.—Of 250 married women operated upon by Landau for fibromyomata, 182 had been pregnant and 68 were sterile, or 27 per cent. Of Winckel's 555 cases, 140 were single and childless, 415 were married and of these latter 134, or 24.3 per cent. were sterile. According to Young, of 238 cases of fibroids in married women, 31 per cent. showed primary sterility, as compared with 10 per cent. sterility for women without fibroids. Of the 182 fertile women in Landau's series, but 84 had given birth to more than two babes. This secondary sterility is usually observed after the development of tumors in women who have already borne children. In addition to this miscarriage occurs in 44.7 per cent. of the cases where conception has taken place, according to Young's series of cases. Thus, women with fibroids average fewer children and cease bearing these children earlier than those without fibroids. The manner in which myomata produce sterility is not known. Fraenkel claims that interstitial tumors have the greatest influence in preventing conception, next in importance are the subserous, while least harmful are the submucous ones. In a series of 2000 cases of women suffering from other pelvic diseases Fraenkel found a primary sterility of but 5 per cent. as compared with 33 per cent. where these growths existed. While it is only in exceptional cases that the direct influence of the presence of the tumor in producing sterility can be proved, yet it would seem that in the great majority of cases the sterility is due to the tumors themselves. It is only fair to presume that most of the lighter inflammatory conditions which coexist are secondary to the fibroids. Certainly the very large percentage of abortions must be attributed to the tumors. Landau does not regard the presence of myomata as of enough importance, as regards conception, to warrant the physician in advising against marriage.

The Relation of Fibroids to Pregnancy, Labor and the Puerperium.—The hypertrophy and increase in the smooth muscle fibers and connective tissues, and the dilatation and extension of blood and lymph vessels is so closely similar to the changes in normal pregnancy, that, in the intramural tumor, there is often little or no evidence of fibroid growth. The tumor, palpable in the non-pregnant state, often disappears during pregnancy, only to reappear in the puerperium. It is difficult to measure the influence which this class of fibroids exerts on muscle contraction, on the development of the child, or contrariwise, which the edema and plasticity of the tissues has to do with changes in the myoma. It is evident that in the puerperium the tumor undergoes a retrograde change, an involution similar to that in the uterus, comprising fatty degeneration, resorption of cell plasm, thrombosis of capillaries, and compression of the larger vessels. Hya-

line and myxomatous degeneration are also seen. These processes, especially thrombosis, may lead readily to edema, hemorrhagic and anemic infarcts and gangrene. Torsion of the pedunculated subperitoneal tumor with its resultant changes, or of the tumor and uterus together may occur after labor. Mechanical insult and infection in the submucous fibroid all the more readily takes place in the edema of pregnancy, leading directly to purulent discharge. In the stress of labor, particularly, as a result of forcible muscular contractions, the growths take on polypoidal formations and become avenues for infection as soon as the mucous edges are damaged, or else hemorrhage is produced. This type of tumor also predisposes strongly to *inversio uteri*.

FIG. 189.—Uterine myomata, subserous, intramural and submucous varieties, with pregnancy.

The influence of the myoma on pregnancy is even less favorable. Hemorrhage and contractions are frequent results, together with transverse presentations of the child, prolapse of the cord and of the extremities, and placenta previa. Premature labor is induced as a result of deficient nutrition in the placenta, of the inability of the uterus to expand, of the expulsion of detached tumors and because of excessive growth of the myomata with mechanical pressure or the induction of uterine contractions. Myomata also tend to cause rupture of the uterus. This accident occurs spontaneously during labor when, as a result of some obstacle in the true pelvis, the child is unable to pass. Finally, postpartum hemorrhage may occur, as a result of atony of the uterine wall or where a tumor might act as a foreign body causing the uterus to relax in effort to expel its contents.

The danger from sloughing of fibroid growths after abortion or labor has been regarded too lightly. Twenty-two years ago Stavely called attention to the danger of puerperal septic infection by collecting and reporting the records of 597 cases in which there was no treatment until labor ensued. Of these 220 died, or 37 per cent. Of another series of 548 cases, 15 per cent. aborted, 307 of these became septic, with a 12 per cent. mortality.

Postpartum inversion of the uterus due to fibromyomata is another grave complication, reports of which are constantly appearing in the literature. Jones has recently reported one such coming on as late as fourteen days after spontaneous delivery. This condition will be considered more fully in discussing the differential diagnosis.

The entire question may be fairly well disposed of by accepting Landau's clinical arrangement by which uterine myomata in pregnancy are placed in four groups.

1. Tumors which give rise to no symptoms. These are often found incidentally during examination in pregnancy or labor. No special treatment is necessary.

2. Tumors causing symptoms which make it necessary to operate. These may be enucleated without interruption of the pregnancy.

3. Tumors producing no general symptoms but the size and location of which make natural delivery impossible or dangerous to mother or child. They should be treated expectantly, with Cesarean section and enucleation at term.

4. Where the objective and subjective symptoms are such that the patient's life is threatened. Interference must be undertaken here regardless of pregnancy. Grad regards cases in this group as seriously as he does malignancy. Susserot gives a mortality of 55 per cent. out of 147 cases; Pozzi likewise gives a mortality of 55 per cent. Rather than therapeutic abortion, Landau advises total extirpation without delay.

METHODS OF DIAGNOSIS OF FIBROIDS OF THE UTERUS.

In the examination of the patient the same methods of diagnosis are employed as in ascertaining gynecological conditions in general. These are, in order: (1) Inspection, (2) abdominal palpation, (3) percussion, (4) mensuration, (5) auscultation, (6) vagino-abdominal, (7) recto-vagino-abdominal and (8) vesico-abdominal palpation. In employing this routine the methods are varied according to the situation of the tumor, whether it be limited to the pelvis or rise into the abdomen.

Pelvic Situation.—If in pelvic situation an interstitial growth would not be recognized by inspection, an abdominal palpation would be of value only if the enlarged fundus rose as high as the plane of the pelvic inlet. Percussion and auscultation likewise would be of no aid. By combined bimanual palpation, however, the growth would be recognized. The uterus is enlarged and hard, but smooth and free,

any asymmetry in its surface being rather a gentle bulging, either of the anterior or posterior walls. The size of the growth and its

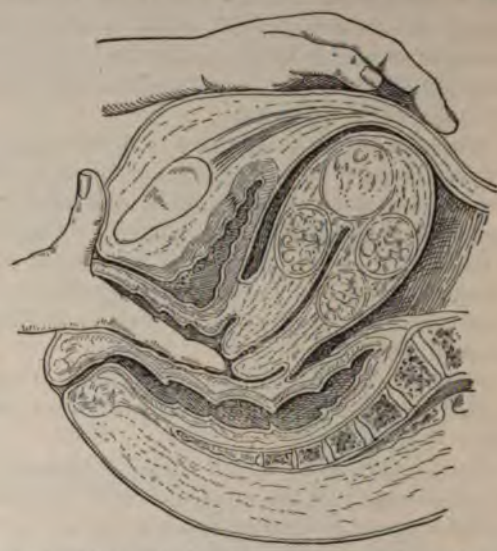


FIG. 190.—Diagnosis of interstitial fibroids of the uterus by vagino-abdominal touch, showing the connection between the tumor and the uterus. (Ashton, Practice of Gynecology.)

FIG. 191.—Diagnosis of interstitial fibroids of the uterus by artificial uterine prolapse combined with recto-abdominal touch. (Ashton, Practice of Gynecology.)

location can usually be better made out by recto-vaginal-abdominal touch. This method is accomplished by introducing the second

finger into the rectum at the same time that the index finger enters the vagina, while counterpressure is exerted upon the abdomen by the

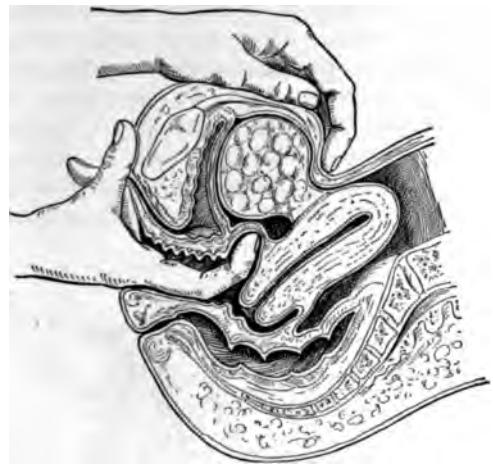
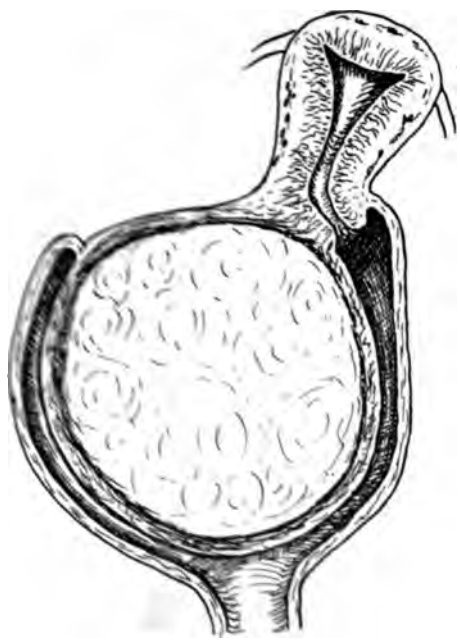


FIG. 192.—Diagnosis of a pedunculated subperitoneal fibroid tumor of the uterus by vagino-abdominal touch. (Ashton, Practice of Gynecology.)

FIG. 193.—Diagnosis of a submucous fibroid tumor of the uterus by abdominal touch combined with the index finger in the uterine cavity. (Ashton, Practice of Gynecology.)

other hand. This enables the examiner the better to palpate up into the pouch of Douglas as well as laterally, thus giving a clearer idea as to the size of the growth, its freedom or fixation in the pelvis and its impaction against neighboring structures.

The subperitoneal tumor is recognized more prominently as a definite nodule growing from some point on the uterine body. If single it may be large enough to push the uterus to one side or into sharp anteversion or retroflexion, or it may press firmly against the pelvic wall, bladder or rectum. When multiple the subserous growths vary in size and project at different angles, so that the entire mass feels not unlike a large knobby potato. In these cases a uterine sound is of value in determining the direction of the uterine cavity. Likewise a sound in the bladder helps materially in isolated cases. It should be emphasized, however, that the use of either vesical or uterine sounds is attended with danger, and that their employment is to be



[illegible] fibroid of the cervix distending the vagina, with the rest of the uterus unaltered. (After Dartigues.)

[illegible] to the extremely doubtful cases. This applies particularly [illegible] sound, owing to the ever-present possibility of pregnancy.

The submucous fibroid produces an enlargement of the uterus that [illegible] and perhaps softer in consistency. Where the [illegible] of normal pregnancy or of threatened abortion can be [illegible] to dilate the cervix and palpate the uterus directly [illegible] explore it with the curette forceps. Since this [illegible] particularly liable to both hemorrhage and infection [illegible] from septic abortion is essential. Where [illegible] pedunculated they are usually visible in [illegible] they have not prolapsed into the vagina. [illegible] the broad ligament, in the pelvic situation, are not

usually differentiated from the subserous variety until operation. They produce an oval swelling on one side of the pelvis, gradually pushing the uterus to the opposite side, though occasionally they appear bilaterally. The mobility of the small subserous tumor is absent and as they often grow rapidly they become impacted in the pelvis, giving rise to serious pressure symptoms. The vesical sound may be of definite aid in such circumstances.

The cervical fibroid is globular at first but soon becomes oval and its pole is apt to be vertical rather than horizontal. This is especially true of those growing in the posterior wall. Vagino-abdominal palpation is usually sufficient for their recognition. In the submucous

FIG. 195.—Globular fibroid in the wall of the fundus, producing an enlarged, but symmetrical, uterus. (After Bland-Sutton.)

type the tumor bulges into the canal in such a way as to produce an apparent effacement, with a dilated sharp-edged external os closely resembling the changes of labor. The writer has in mind one such case in his own experience. When the anterior wall is involved the bladder and urethra are particularly apt to be discommoded, and may require the use of the vesical sound.

Regardless of the variety of tumor, in the pelvic situation impaction will result if the tumor, as it increases in size, does not rise into the abdomen. Lateral pressure particularly results in venous obstruction with resultant cyanosis and edema. While much more frequent in the larger abdominal growths, discoloration of the vulvar and vaginal

mucous membranes may be seen on inspection. If associated with swelling of the labia this condition is always suggestive of early pregnancy. Inspection, therefore, should not be omitted as a method of diagnosis even in small fibroids.

Abdominal Situation.—Where fibroid tumors have increased in size until they distend the abdomen any differentiation between varieties is of little importance. Here inspection is first employed and in many instances, where the abdominal wall is soft and relaxed, the various nodules may be seen. The asymmetry, irregularity and yet continuity of the growth is, however, best appreciated by palpation. This method also serves to ascertain the consistency of the mass, whether it is hard, soft, firm, resilient, or cystic, to determine its fixation or mobility, and to elicit such tender points as may obtain. By percussion the tumor is more definitely outlined and differentiated from other factors in abdominal distention such as free fluid, tympanities, etc.

By mensuration the size of the growth is estimated. Here the best points by which to measure are the fixed ones, such as are used in determining the growth of the pregnant uterus. Thus the height of the fibroid above the symphysis or below the ensiform is taken in centimeters. In extremely asymmetrical tumors such fixed points as the crests or anterior superior spines of the ilia, or the free border of the ribs are often used.

In auscultation there exists a method of diagnosis which is of considerable value and yet which is most neglected. In large tumors the ever-present probability of pregnancy, even in the presence of a readily recognized myoma, makes the use of the stethoscope essential. It may be true that most pregnancies are overlooked before the fetal heart can be heard, yet the element of doubt enters into the situation so persistently that no method of differentiation should be omitted. Aside from this, the *bruit* from the large vessels of the uterine fibroid is more characteristic of this tumor than of any other found in the abdomen.

Combined bimanual palpation in tumors abdominally situated is carried out exactly as described for those limited to the pelvis. This reveals that the abdominal growth is continuous with that found in the pelvis, either by continuity or by mobility. The possibility that the abdominal tumor may be different in nature and origin from the pelvic one is a point not to be lost sight of.

Cardinal Symptoms.—The cardinal symptoms by which the diagnosis of uterine myomata is suggested are as follows:

1. Hemorrhage, in the form of menorrhagia, sometimes metrorrhagia.
2. Leucorrhea.
3. Pain.
   - (*a*) Dysmenorrhea.
   - (*b*) Pain in the tumor.
   - (*c*) Pain in surrounding structures.

These symptoms depend largely upon the situation of the tumor,

PLATE VIII

Specimen Injected to Show Arterial and Venous Blood-supply.

Subserous, intramural and submucous myomata, showing rich venous supply of the myometrium, greater than in the non-myomatous uterus, and the relatively anemic (venous) myomata, all of which have an arterial supply. (After Sampson.)

its size, the condition of the mucous membrane, changes in the tumor, and the condition of the surrounding structures.

1. HEMORRHAGE.—Menstrual periods increasing in duration and amount of flow, with pain and clots, is the most characteristic feature of uterine myomata. In some cases the hemorrhage is irregular in time and duration and comes on without respect to a regular period. In other cases there is no hemorrhage at all and some women with large tumors and marked pressure symptoms have gone through a normal menopause with a gradually decreasing menstruation until amenorrhea supervened at the normal age. Why some fibroids are productive of hemorrhage and others not has been a subject of discussion for years, until Sampson's excellent work in 1912 and 1913 went far to explain this apparent inconsistency. Sampson studied a large number of injected specimens and found that fibroids, with respect to their blood-supply, may be divided into two classes: (*a*) Peripheral, having the blood-supply from the peripheral branch of the arcuate artery, usually intramural, subserous, intraligamentous or retroperitoneal. (*b*) Radial, having the blood-supply from a radial branch of the arcuate artery, primarily intramural, but becoming subserous or submucous. In all myomata the blood both enters and leaves the tumors by the arteries, the exchange to veins taking place beyond them. All veins, therefore, are in the myometrium, the mucosa being supplied with capillaries only. These veins are relatively few and inadequate to handle any excessive return supply of blood.

Subserous fibroids while small are not very vascular, only those more than 10 cm. in diameter bringing more blood to the uterus and hence producing a congestion of the venous side. Small or medium interstitial tumors are usually less vascular than the normal myometrium, not altering the blood-supply unless they are numerous, or unless the organ shows a *hypoplasia muscularis uteri* or a *myofibrosis uteri*. Large interstitial tumors require enlarged arteries and a dilated venous plexus. Both small and large ones, however, interfere with muscular efficiency, as a result of which menstrual bleeding goes unchecked. In the submucous variety, as has been pointed out, the endometrium is atrophic over the tumor. Here bleeding comes from the other portion of the mucosa where the venous supply is abundant or excessive, especially if a hyperplasia has already developed. Thus the submucous tumor brings arterial blood directly to the mucous membrane, a structure admirably adapted to produce venous engorgement. Bleeding in myomata, then, like that of menstruation, is venous and varies much in different growths. Only where a fibroid is necrotic or has become malignant may the hemorrhage be arterial. Sampson regards the influence of the tumor in interfering with muscular efficiency as the important factor. It is not the amount of blood in the uterus or pelvic veins which determines the amount of blood lost at menstruation as much as the control of this blood by the uterine musculature, that is, uterine tonicity.

It goes without saying that hemorrhage is made worse by exertion, emotion and coition.

2. LEUCORRHEA.—This takes the form of a profuse mucoserous discharge most commonly seen in those larger tumors associated with pelvic congestion. It is due to an excessive secretion of the cervical mucous-secreting glands and to serous transudate from the corpus. From retention in the vagina it becomes opaque and yellow, and frequently it will be blood-stained. In case of coëxistent inflammation it becomes increased in amount. The foul odor of necrosis is absent except in case of infection and sloughing or of malignancy.

3. PAIN.—(*a*) *Dysmenorrhea.*—Many simple, uncomplicated tumors, not involving the mucous membrane, are not associated with menstrual pain, but in most cases of medium-sized or large growths, the ordinary discomfort of menstruation is aggravated. Where the uterine cavity is made tortuous and bleeding is excessive the expulsion of clots will be attended by uterine colic. The more typical dysmenorrhea is produced, however, by that type of uterus which is flaccid and where the tumor is submucous and pedunculated. Here the growth acts as a foreign body, efforts to expel which will cause great pain, often likened to pains of the first stage of labor. In rapidly growing fibroids, also, there is apt to be dysmenorrhea.

(*b*) *Pain in the Tumor.*—It may be said that a typical uncomplicated fibroid does not, of itself, hurt, especially if it is lying latent. A rapidly growing tumor, however, is very apt to be painful. This is particularly true of the interstitial and submucous varieties and the pain is apparently due to rapid enlargement of the uterus. More definitely, though, is pain a symptom of those tumors which are undergoing degeneration. Here, even in the absence of hemorrhage or leucorrhea, if pain is present in a known uterine tumor, one must suspect necrobiosis. If in addition the patient is sick, *i. e.*, feels ill, with loss of appetite, fever, malaise, etc., necrosis in the tumor will almost certainly be found. On palpation this fibroid will also be tender.

(*c*) *Pain in Surrounding Structures.*—By the time the tumor has grown sufficiently large to become impacted in the pelvis, or to press upon other pelvic or abdominal structures, pain has become, next to hemorrhage, the most marked symptom of uterine myomata. At the least this is expressed by a constant bearing down and sensation of weight and fulness in the pelvis. Tumors in the pelvic situation, particularly of the intraligamentous variety, give rise to such pressure symptoms. In addition comes rectal tenesmus and obstipation, or vesical tenesmus and urinary frequency or at times incontinence. Occasionally retention of the urine will be produced where the bladder is raised into the abdomen with elongation of the urethra. Ureteral obstruction with dilatation is not so infrequent where the tumor is so situated as to exert pressure laterally and posteriorly. Following this comes hydronephrosis and pyelitis, whereupon additional pain is felt in the region of the kidneys.

Neuralgic pains are frequent in large fibroids and cause a great deal of distress. These are present oftenest in the sacral and lumbar regions, with radiating shooting pains down the legs, but are experienced also in the abdominal wall after it has become distended. Where the tumor rises high in the abdomen such pains are felt as far up as the lower intercostal region. Often they are accompanied by the characteristic tender points of neuritis. Whether these pains are due to pressure on the spinal nerves or to stretching of the various tissues affected is uncertain.

Pressure on the pelvic veins is another cause of pain. In this way varices are produced at the anal and vulvar regions, as well as in the legs, with resultant localized edema and cyanosis. Frequently there results pruritus and various skin lesions, such as eczema, all of which add to the general condition of distress. Even in moderately large growths enormous masses of varicosed veins are seen in the infundibulo-pelvic and broad ligaments. It is inevitable that these, too, should add their portion to the sum total of suffering endured by the patient.

In abdominal fibroids rising above the umbilicus pressure is exerted upward, discommoding the stomach and upper intestinal tract, or the liver and gall-bladder on the right side and the spleen on the left are impinged against. When the diaphragm is reached the action of the heart and lungs is interfered with. Cystic fibroids particularly may grow so enormous, the so-called "giant tumors," as not only to distend the abdominal wall but to elevate the diaphragm and force the lower ribs and sternum to flare out. In such a case a great variety of gastro-intestinal and other symptoms will be produced. Weight and distress in the epigastrium, flatulence, palpitation of the heart, dyspnea and the entire train of symptoms represented by the term, dyspepsia, are the result.

Pain is produced also by adhesions which form between fibroids in the abdominal situation and other structures, such as the omentum and intestines. This is more apt to be colicky in nature, representing intestinal kinking, with partial obstruction, and possibly pain when defecation does occur. Occasionally there may be alternate periods of obstipation and dysentery.

Fibroids in the pelvic situation may become adherent to the sigmoid flexure, to the rectum, to the cecum or appendix, to a loop of the ileum, to the bladder, or to the uterine appendages. Local pain in any of these structures will result. The tubes may give rise to pain of themselves, as may the appendix, but when this occurs it is due to inflammatory activity and differs little or none from salpingitis or appendicitis where fibroids are absent. The ovaries may be factors in pain in the same way, though here pressure directly on the part of the tumor may be the exciting cause.

In general, it may be stated that a woman suffering from fibroids of the uterus may go along for years with little or no distress. On the other hand, as a result of constant suffering she becomes markedly

run down and exhausted. She may be thrown into a profound anemia by a sudden severe hemorrhage, or, as the result of a constant loss of blood, may have existed under the blighting effects of chronic anemia for years. If heart disease or hepatic changes come on her condition goes from bad to worse. Copremia results from chronic obstipation, and hydronephrosis, ascites and temporary paralysis all do their share in reducing vitality.

DIFFERENTIAL DIAGNOSIS OF FIBROIDS OF UTERUS.

Pelvic Peritonitis—This condition is usually limited to the pelvis and is chiefly differentiated from fibroid tumors by the history of infection. The patient becomes suddenly ill at some time, with sharp pain low down in the abdomen or pelvis, chills and fever, and a moderate degree of nausea and vomiting. If puerperal in origin it comes on soon after labor or abortion; if tubal, there may be repeated attacks. The abdomen is distended below the umbilicus, tender, tympanitic and rigid during the acute stage. The blood count shows a leukocytosis of 10,000 to 15,000 in tubal infection, or 15,000 to 30,000 in puerperal sepsis. As the acute stage subsides the symptoms disappear except that deep pressure over the pelvis elicits tenderness and a slight leukocytosis persists if the conditions become chronic. In rare instances the peritonitic tide will rise above the pelvis and leave a mass palpable above the symphysis in the chronic stage. This mass is made up of adherent and infiltrated intestinal coils and omentum; hence, it produces a swelling always fixed, usually tender and less definite in outline than one due to a fibromyoma. Very rarely a sactosalpinx will rise into the abdomen. By vaginal touch the uterus is made out to be *fixed*. This is so characteristic that fixation of the uterus is always suggestive of chronic pelvic peritonitis. The uterus may be in normal position or displaced. It is apt to be slightly enlarged, soft and boggy and tender. It is held in this fixed position by the lateral masses representing the diseased tubes and ovaries which lie high up and fill the pelvis from side to side, the involvement usually being bilateral. These masses are also fixed and tender, less definite than pelvic fibroids and not so hard. Sometimes they extend down posteriorly, filling the cul-de-sac. If, of puerperal origin, the pelvic mass is more apt to be unilateral or posterior, pushing the uterus, both cervix and corpus forward into anteposition, and bulging down between the vagina and rectum, thus shortening the vaginal tube. Representing involvement of the pelvic cellular connective tissue this type of infection also bulges down laterally, shortening the fornix on the affected side. Pelvic cellulitis is particularly apt to liquefy and give the sign of fluctuation, though this occurs also in pyosalpinx under favorable conditions. Menorrhagia may occur in pelvic peritonitis but it is not so consistent as in fibroid tumors; metrorrhagia is less frequent.

A subserous, supravaginal, cervical tumor, or one low down in

the corpus, or a broad ligament fibroid, or one impacted in the pelvis and softened as a result of some degenerative process, or of pregnancy, may very closely resemble the masses of parametritis or pyosalpingitis. The coexistence of both conditions must always be thought of. Thus multiple small nodules in the corpus may be buried so completely in layer after layer of peritonitic adhesions as to be clinically lost, the two conditions being resolved into a common, fixed, tender mass.

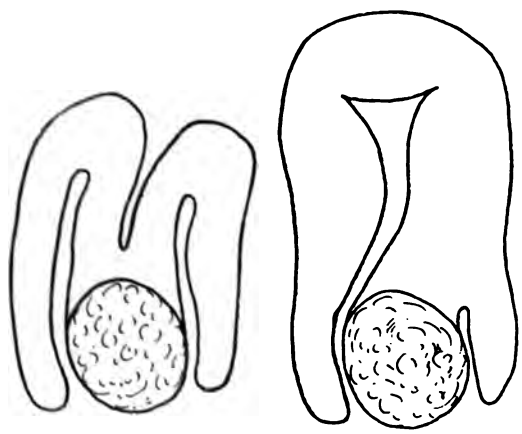
Pelvic Hematocele.—With this condition the history is suggestive of early gestation. One or more menstrual periods are missed and the patient may regard herself as definitely pregnant. Then suddenly she is seized with severe pain in the lower abdomen, faintness, vertigo, nausea and vomiting, and possibly evidences of internal hemorrhage. A bloody vaginal discharge appears and, after twenty-four hours, some fever. The blood analysis shows a decreased number of white cells and a low percentage of hemoglobin. With the crisis the abdomen becomes rigid, tense, tender and distended, with boggy resistance and dulness above the pubes. Vaginally there is a tumor on one side which may be isolated from the uterus. It will be close against the pubis and fixed by pressure. After forty-eight hours this mass becomes harder and bulges down into the cul-de-sac in the median line, from which position it cannot be displaced. A tubal pregnancy, rupturing between the folds of the broad ligament might produce a hard firm swelling very like a fibroid impacted in the pouch of Douglas, with the uterus raised up above the pelvis resembling a subserous pedunculated nodule. As a matter of fact pelvic hematocele usually is readily distinguished from uterine myoma, being oftener mistaken for ovarian cyst or pelvic abscess.

Ectopic Gestation.—This condition occasionally requires differentiation from fibroids before rupture. History will again bring out the presumptive signs of pregnancy. The patient complains of pain in one side, always unilateral, of a sharp cutting nature. The abdomen will be negative or deep palpation over the painful area will elicit tenderness. By vaginal touch a small tender mass will be made out on one side, which will be separate from the uterus and not hard or nodular. It is much more apt to be mistaken for acute salpingitis or ovarian cyst. If allowed to go on it leads almost inevitably to abdominal crisis.

Abortion.—The threatened termination of pregnancy in the early weeks or months may strongly resemble fibroid tumors. Thus, there may be bloody discharge or definitely irregular bleeding throughout, as would be the case in placenta previa. This would obscure the history of gestation. Morning sickness may be absent and breast changes are of little value in multiparæ. Cyanosis and a soft, patulous cervix should be more indicative of pregnancy, though they might be present in the case of a submucous pedunculated tumor where effort was made to expel it. Such a condition also would be associated with colicky and bearing-down pains very like those of abortion. The uterus is enlarged, symmetrical and resilient, rather than hard and nodular.

Incomplete abortion would not be mistaken if the fetus had been secured. Without this, the enlarged, soft, boggy uterus with gaping cervix and bloody contents should be sufficient after a history of preceding amenorrhea. With infection, however, especially of a saprophytic type where the patient is not very ill and the uterine discharge has become foul, incomplete abortion may be very like a sloughing submucous fibroid. Exploration of the uterus *per vaginam* is the most direct method of determining the true condition.

Displacement of the Uterus.—This is a condition which frequently misleads the novice but rarely confuses the experienced clinician. Anteflexion and retroflexion are apt to be mistaken for small subserous fibroids of the anterior or posterior uterine wall respectively. The ease of diagnosis depends on the thickness and firmness of the abdominal wall. Simple lateral dislocation leaves the opposite side



a *b*

FIG. 196. Diagram of (*a*) incomplete inversion of the uterus due to a submucous fibroid of the fundus simulating an intra-uterine polyp, and (*b*) a submucous fibroid without inversion. (After W. C. Jones.)

of the pelvis empty. Mobility of the uterus is a valuable aid here, since it makes it possible to place the organ in various positions whereby it may be more readily palpated. Fixation of the uterus is always suggestive of inflammation rather than tumors, but this might be brought about by a fibroid large enough to become impacted. The use of the uterine sound is advisable in obscure cases and this, together with recto-vaginal palpation will determine conditions.

As has been suggested, the uterus may be elevated above the pelvis, where, through the abdominal wall, it will feel like a subserous tumor. This may occur as a result not only of retroperitoneal hemorrhage but of parovarian cysts, hard tumors of the broad ligament, and possibly pelvic abscess.

Inversion of the Uterus.—This rare accident to the uterus resembles a large fibroid polyp that has been expelled through the external os.

It is exceedingly infrequent and usually occurs a relatively short time after labor, being caused by extreme pressure on the fundus in efforts to expel the placenta. It may also be due to a fibroid polyp hanging from the fundus uteri and pulling the wall after it as it is extruded through the cervix. Metrorrhagia and pain are the features of this condition, the inverted uterine wall appearing red and edematous, with a mucous membrane over it instead of a shining pink capsule. Bimanually no uterine body is found in its place but rather a cup-shaped depression just above the cervix. A sound can be passed the normal distance in case of a polyp whereas in inversion it cannot be passed at all. Great care must be exercised in using the sound as the uterine wall is soft and boggy and might easily be

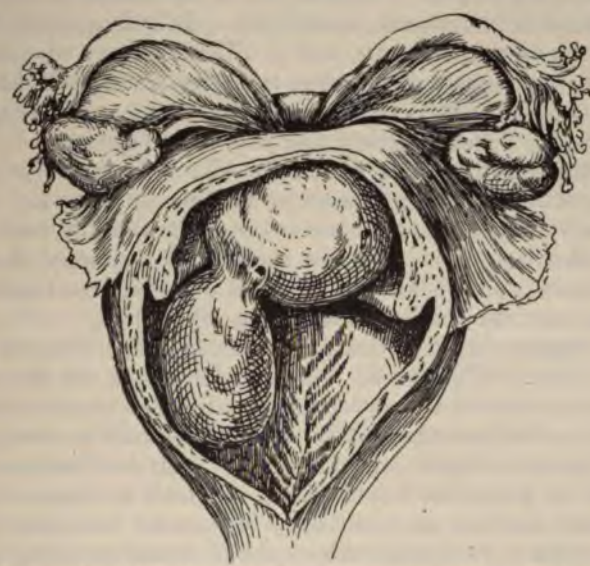


FIG. 197.—Pedunculated fibroid growing from the fundus with partial inversion of the uterus. (After Bland-Sutton.)

perforated. By rectal touch, with a sound in the bladder, it will be found that the uterine body has disappeared, leaving the pelvis empty. The diagnosis is not difficult in young women but in old it may be impossibe without the aid of anesthesia and thorough exploration.

Mucous Polyp.—Its influence in producing hemorrhage and its aptitude for malignancy make the mucous polyp important. Metrorrhagia is the symptom. The uterus is seldom enlarged and never asymmetrical or hardened. The growth may be seen hanging from the external os as a bright red body varying in size from a pin-head to one's finger-tip. The diagnosis is readily made by exploration of the uterus.

Fibrosis Uteri.—In this condition the uterus is enlarged and hard but symmetrical and free, and menorrhagia is the symptom. The

patient has usually been through a number of pregnancies, fibrosis representing a degree of chronic subinvolution. The uterine wall is thickened and shows a marked increase in elastic connective tissue, an abundance of which is seen running irregularly between the relatively diminished muscle bundles. The bloodvessels are large and thick-walled and arranged in clusters, surrounded by this connective tissue. The mucosa is seldom hyperplastic but the glandular elements are emphasized by a relative decrease in the interstitial tissue. Not infrequently this condition will be associated with one or two small intramural fibroid growths or with numerous "seedlings."

Chronic Metritis.—In the discussion of pelvic peritonitis this condition was partially described. The uterus is enlarged, soft, boggy and tender. As a rule, it is fixed, or, if not fixed, its mobility is impaired and its movement causes pain. It is frequently displaced but always symmetrical. Its wall is thickened but edematous and smooth on cross-section, showing extensive round-cell infiltration. Its mucosa is very often hyperplastic and hence menorrhagia is its chief symptom, with leucorrhea and pain in association.

Subinvolution of the Uterus.—Here the history is that of a preceding pregnancy, with the patient, in all probability, not nursing the child. It is characterized by more or less continuous bleeding with or without dysmenorrhea. The uterus is considerably enlarged, is soft and boggy, frequently displaced, but free. It is symmetrical and suggests uterine myoma subjectively rather than objectively.

Cystic Tumors of the Ovary.—Differentiation between ovarian cysts and fibroid tumors may be very difficult if the fibroids have undergone edematous or cystic change. Careful history-taking and close study and examination of the case are essential to arriving at the correct diagnosis. Again, an ovarian cyst that had become fixed to the uterus by adhesions would closely resemble a subserous fibroid. Menstruation may go on normally in cystomata but when it is disturbed it tends toward amenorrhea, the intervals becoming increased or the duration of the flow less, or the amount of the flow decreased. There will be no dysmenorrhea but pressure symptoms in the pelvis may be severe.

If in the pelvic situation, the cyst fills the cul-de-sac and pushes the entire uterus forward or upward; if in the abdomen and large, the uterus is pushed down against the pelvic floor. As a rule, the cyst and the uterus may be made out separately whereas the fibroid is a part of the uterus. While some ovarian cysts are very hard, this is rather tenseness than solidity. Typically, fluctuation is the characteristic finding on digital examination, plus mobility. In fibrocystic tumors the cyst forms but a part of the growth, and fluctuation is limited in extent and never so clear, while harder nodules will be found attached beneath. In ovarian cyst fluctuation is of the entire mass wherever in the pelvis or abdomen. The cyst is also more mobile than the fibroid, since its pedicle is longer and freer. This is especially marked in the presence of ascites, when the cyst may

be moved about or ballottement elicited. As a result of there being no loss of blood in ovarian cysts there will be no anemia, as in fibroids—at least not before the cyst becomes malignant. The possibility of both tumors being present in the same case should not be left out of mind.

Solid Tumors of the Ovary.—Hard ovarian growths are very rare and often bilateral. They may resemble subperitoneal pedunculated fibromata, though they are extremely hard and apt to be associated with ascites, especially if malignant. In every case the subjective and objective symptoms of uterine involvement are absent, so that the uterus remains as a separate structure of normal size somewhere in the pelvis. In fibroids both ovaries may be palpated separately. In ovarian carcinoma and sarcoma the signs of cachexia and metastasis eventually appear, conditions which never develop with uncomplicated fibromata.

Pregnancy.—In a typical case normal pregnancy does not closely resemble fibroids. There is the history of amenorrhea with the nausea and vomiting of the early months, cyanosis of the vagina and softening of the cervix. The uterus is enlarged, soft, symmetrical, resilient, free and bimanual palpation reveals its hardening and softening, or the alternating contractions. Later on in the abdominal situation, the probable signs of pregnancy come on, to be followed by the positive ones, auscultation of the fetal heart and the appreciation of fetal movements. On the other hand, pregnancy may be so atypical, and fibroids so innocuous or so modified by degeneration, as to render a certain diagnosis extremely difficult. Thus, in pregnancy irregular bleeding may obtain from the start and morning sickness be entirely absent, while the uterus increases in size. The breast changes are of but relative value in the multipara who has nursed. Fetal movements may not be appreciated by the patient or are dissipated in polyhydramonis. A rapidly growing true myoma, interstitially situated, or one softened by degeneration, may enlarge the uterus symmetrically for a long time. Changes in consistency are noted from time to time. Vaginal pigmentation and softening of the cervix are signs present in all fibroids that produce pelvic pressure. Menorrhagia and metrorrhagia may be absent and patients have been known to pass through a normal menopause while bearing large fibroid tumors in the uterus.

In the abdominal situation the fetal heart may not be heard, as a result of position of the fetus or of its death, or of an obese abdominal wall. With the positive signs gone it is not difficult to mistake pregnancy for a newgrowth. The resemblance borne becomes particularly close in case the fetus dies and is retained for a length of time. Here, in addition to similar physical signs, the patient would show general malaise and increased leukocytes exactly as in fibroids with necrobiosis.

Finally, in differential diagnosis the possibility of pregnancy coexisting with fibroids should never be lost sight of. This coincidence has been discussed elsewhere.

Malignant Tumors of the Uterus. (*a*) *Sarcoma.*—Primary sarcoma of the uterus involving the corpus appears in diffuse or rounded, lobulated form, not encapsulated and softer than fibroid growths. Single or multiple nodules, varying in size, tend to form polyps on the inner surface. In the cervix it appears in the form of solid polypoid nodules, smooth and glistening, or as a grape-like, cystic formation, sometimes racemose. These cystic nodules contain a thick, sticky fluid. Particularly in the corpus variety is the differentiation from fibroids difficult and here the microscope will be required. The presence of the characteristic round or spindle cells arranged in homogeneous masses gives the diagnosis. Differentiation is really suggested more clearly in the anamnesis. Sarcoma occurs in the early years of adult life, as does the fibroid, but it runs an extremely rapid course, and is quite as rare as the latter is frequent. There is metrorrhagia rather than menorrhagia and a foul, watery, blood-stained discharge. The pain is independent of menstruation, later becoming intense and boring in nature, yielding only to opiates. Metastasis develops late but cachexia is early and marked.

(*b*) *Carcinoma.*—The history here is very similar to that of sarcoma. The course of the disease is probably somewhat less rapid and it occurs most frequently during the fourth decade of life. Ulceration is more extensive and appears earlier but hemorrhage is proportionately less profuse. Metastasis appears earlier and may become very extensive. Pain and discharge are about the same. Carcinoma of the portio appears as a cauliflower growth, friable and bleeding easily. In the cervical canal there is thickening and induration in the first stage that may closely resemble an interstitial fibroid. It occurs, however, much more commonly here than do fibroids. In the corpus, carcinoma is rare and fibroids common. After the stage of ulceration has been reached there should be little difficulty in differentiation. The characteristic foul and watery discharge with irregular profuse hemorrhages, rapid loss in weight and strength, and the cachectic appearance go to make up a symptomatology very unlike that of myoma. While a woman may become profoundly anemic as the result of profuse bleeding from uterine fibroids, the anemia rapidly disappears under treatment if the hemorrhage can be stopped. This is not true in either sarcoma or carcinoma, the anemia becoming a secondary one and yielding very slowly, if at all, to remedial measures.

On palpation advanced carcinoma appears as an ulcerating crater involving the cervix and the vaginal vault, the entire mass held in fixation by a surrounding area of dense infiltration which extends laterally into both broad ligaments as far as the pelvic walls. Ulceration and fixation with blood-stained, foul discharge are the characteristic findings in carcinoma.

(*c*) *Chorio-epithelioma.*—This extremely malignant growth so closely resembles carcinoma or sarcoma in its course that it requires little description by way of differentiation from uterine myoma. It more or less closely follows labor or abortion, depending absolutely upon a

preceding pregnancy, and vesicular mole particularly suggests it as a consequent. It always involves the corpus uteri, causing enlargement of this structure and may extend to the broad ligament. Its growth produces a diffuse mass, not well defined, so that it would be mistaken for an interstitial or submucous fibroid. Chorioepithelioma may also occur primarily in the tube. One such case, with adhesions, closely resembled a subserous fibroid and peritonitis.

Other Conditions Requiring Differentiation.—(*a*) *Hard Tumors of the Tube.*—Hard tumors of the tube are among the rarest findings in the pathology of the female pelvis. They are usually fibroid in nature and free, resembling subserous pedunculated uterine fibroids.

(*b*) *Echinococcus Cysts.*—Bland-Sutton refers to 3 such cases, 1 of his own occurring in the mesosalpinx, 1 in the wall of the uterus at its fundus, and 1 that obstructed delivery, all of which at first were thought to be fibroids.

(*c*) *Movable Kidney and Spleen.*—Cases in which either a kidney or the spleen has been found in the pelvis are not so rare. In many instances these mobile organs, enlarged and distorted by congestion, have been mistaken for uterine myomata. On the contrary, a subserous fibroid with a long pedicle has been diagnosticated as movable kidney. In the abdominal situation the kidney or the spleen should not resemble fibroids, but in the pelvis they may appear to be closely united with the uterus. Cases are on record where the spleen has been so adherent to the uterus as to be recognized only after microscopic examination in the laboratory.

TREATMENT OF UTERINE FIBROMYOMATA.

Palliative.—1. **Drugs.**—That proportion of small fibroids which produces no symptoms requires no treatment. Since the great majority of them, however, produce excessive bleeding in some degree, the use of drugs marks the beginning of treatment. Ergot has the effect of contracting bloodvessels and of stimulating contractions of the uterine muscle. For hemorrhage it is given in the form of its fluidextract, 15 to 30 minims every four to six hours. A better preparation is the ergotin pill, 2- to 5-grain doses every four to six hours. The pill acts more slowly but its effect is more continuous and its administration more convenient. In institutional practice ergot is often given by deep intramuscular injection of its sterile preparations. Hydrastis acts as a vasoconstrictor and also influences uterine contractions favorably. It is used much the same as ergot, the fluidextract, in doses of ½ to 1 dram three or four times daily or the hydrochlorate, gr. ½ to gr. 1 every six hours. Stypticin (cotarnin hydrochlorate) arrests hemorrhage by its astringent action or by directly affecting the blood. The dose is 2 to 4 grains four times daily or a 10 per cent. aqueous solution may be given hypodermatically. Styptol (cotarnin phthalate) is another derivative of opium that is both hemastatic and sedative and is well liked in dysmenorrhea. It is well borne by

the patient in doses of gr. ii to gr. iii twice daily. For purely sedative effect or where the patient is nervous the bromides and iodides are also prescribed. Calcium lactate, dram ½ every other night, is of benefit in some cases of profuse irregular and continued bleeding, by increasing the coagulability of the blood. The chloride of calcium, gr. xl in solution daily, is given for the same purpose.

Taking all in all, in a large series of cases it will be found that ergot in some form will give better results than other drugs in three out of four cases. Moreover, it may be given for long periods of time with no other ill effect than some increase in blood-pressure. Some observers have claimed that in certain instances the size of the tumor has decreased under its administration.

2. **Glandular Therapy.**—In view of the theory that fibroids may have their inception as a result of some disturbance in the ovarian secretion, their treatment by extracts of various ductless glands has been instituted. Thus it has been suggested that thyroid extract given over a long period of time, if well borne without constitutional annoyances, may diminish bleeding and even cause some tumors to decrease in size. Sufficient data has not been acquired thus far in order to pass judgment on this question. The same is true regarding the use of suprarenal extract. Producing a secretion that probably tends to neutralize the ovarian hormone, its effect is so ephemeral as to warrant no deductions in its behalf at this time.

3. **Topical Applications.**—Aside from their influence in temporarily relieving pain or hemorrhage, local treatments are of little value. In sudden severe hemorrhage a tight vaginal pack, placed well up in the fornices about the cervix, may check the bleeding for the time being. Tampons are useless, unless to relieve vaginal irritation. Warm douches of normal saline solution alleviate pain and irritation, but should not be too prolonged, nor too hot, nor too frequently repeated.

4. **Rest and Posture.**—Rest in bed is of the first importance during the days of hemorrhage, and longer if the patient is weak from anemia. For pressure symptoms rest is also of value especially if the pelvis be elevated. But where the tumor is very large, pressing against the diaphragm, this will not do. The patient must then lie on the abdomen or side. In smaller growths the knee-chest position may be assumed to advantage for fifteen minutes at a time, three or four times daily.

In general it may be said that the patients must be well fed and have as much exercise as conditions make possible. They should be given plain, nourishing foods if anemic, especially plenty of meat. If the hemoglobin is not decreased and they are obese, the diet and exercise should be so arranged as to reduce the adiposity and to increase muscular tone. Cardiac and renal changes will require treatment, both of a dietary and pharmacologic nature, not only to improve the general condition but to prepare the patient for operation. Likewise the lungs may require attention, especially if emphy-

sema or chronic bronchitis be present. Occasionally an enlarged thyroid will produce pressure symptoms on the trachea so that this will have to be relieved first, though more often operative extirpation of large fibroid will bring about beneficial changes in the goiter.

5. **Electricity.**—The continuous current was employed by Apostoli in 1886, and for many years after it was a popular method of treating uterine fibroids. The positive electrode was placed in the uterus, the negative on the abdominal wall over the tumor with a large pad. The current was started low and increased gradually up to 50 or 80 ma., held there for five minutes, then gradually reduced. One or two such treatments were given weekly, until the maximum strength of the current could be employed. In the long run the use of the continuous current proved to be unsatisfactory and, during more recent years, its use came to be limited to women approaching the menopause, or where operation was refused or contraindicated. Today this method has given away entirely to the use of the *x*-ray and to radium.

6. **Radium and the X-ray.**—In 1895 Smyly referred to the care of the stump following subtotal hysterectomy for uterine myomata as "the burning question of the day." If there is a still "question of the day" twenty-five years later, in the treatment of these same tumors it has to to do with the value of radium and the *x*-ray. For ten years that question has gradually grown in importance, as experience grew and improvement in the method of application developed, until today all radiologists and many clinicians have come to regard the beta and gamma rays as not only palliative in the treatment of fibroid tumors but as definitely curative. Technically the application of radium and *x*-ray has been improved until the tumors treated have disappeared and the dangers incurred have become negligible. On the other hand, the technical perfection of modern gynecologic surgery is nowhere more brilliantly demonstrated than in the extirpation of uterine fibroids. Standing as we do then, between these two opposed and yet equally expert methods of treating a common and important disease, the writer will be content at this time to present in a very brief way the *rationale* of radiology as applied to fibroid tumors and the results obtained.

When it was first discovered that the application of the *x*-rays would cause a cessation of uterine hemorrhage this was attributed to the resultant inactivity, or temporary deficiency, of the ovary. In treating bleeding fibroids, however, not only did the hemorrhage cease but the fibroids, in most instances, decreased in size. It is now recognized that the ovary does cease to ovulate, as the result of gamma-ray influence, so that the uterine mucosa is not influenced to menstruate, but it is probable that the ovarian internal secretion is not markedly inhibited. Evidence has been produced also to show that the shrinkage which takes place in fibroid tumors is not merely the result of ovarian deficiency, menopause reaction, in other words, but that this important change is brought about by a definite action on the bloodvessels of the capsule

and on the cells of the tumor itself. Thus R. Meyer has shown that, as the result of *x*-ray penetration, extensive atrophy of the myoma cells takes place, with sclerosis and moderate hyaline degeneration of the fibrillæ. The vessels, especially in the outer portion of the wall, were extremely sclerosed. As a result of radium applied in the uterine cavity Cheron found that the musculature of the growth showed profound vascularization with hemostasis by obliteration of the vessels, and that too, without causing gangrene of the mucous membrane. Krönig and Lange also regard the tumor retrogression as due to the direct action of the ray on the cells of the growth.

The *x*-ray is applied in two ways: By frequently repeated light doses, and by deep massive doses with the hard tube, in series at infrequent intervals. This method was devised by Albers-Schönberg in 1908 and is the one in most general use today. Radium and mesothorium are applied in capsules, properly filtered, which are placed in the vagina or directly within the uterine cavity. In some instances the *x*-ray has been used externally and radium internally at the same time.

According to Gauss the basic idea in employing the radio-active emanations is to secure the highest possible dose in a unit of time for as long as possible without burning the skin. Thus he developed the so-called "cross-firing" principle, *i. e.*, tubes on the right and left sides of the abdomen, at oblique angles, and two at the back. A tube may also be placed in the center of the abdomen and in the vagina and rectum as well. This gives a seven-field method with three sittings in six weeks. More recently Gauss has combined this method with mesothorium. Fifty milligrams of mesothorium in a gold capsule 1.2 mm. thick and inclosed in rubber to avoid secondary rays is placed in the vagina two or three times in twenty-four hours. Then a rest of two or three weeks is allowed before another treatment.

Béclère employs the *x*-ray in deep, massive doses, one sitting a week, exposing one area at a time, the right side, then the left, then the sacral region. In large tumors the abdominal wall is divided into several areas, each about 10 cm. in diameter. The skin focus distance is 18 cm. to 20 cm., with an aluminum filter 1 or 2 mm. thick and 8 cm. from the skin. At least two irradiations with a 10 cm. lead glass tube are given at each sitting. Treatments are instituted regardless of menstruation. Indeed, Pfahler claims that the most favorable time for raying is just after a menstrual period or at the time corresponding to one. By one of the established methods Heimann estimates the time for producing erythema in a given case. Three fields for exposure are chosen on the anterior abdominal wall and two on the back. One-half of an erythemal dose is applied to each field in turn on five successive days. An interval of eight days is allowed between two series and two or three weeks after the third series.

Even the most enthusiastic advocates of irradiation in the treatment of uterine myomata do not employ it in every case. Thus Pfahler would limit its use: (1) To all cases in older women in whom

there is already a well-advanced anemia; (2) to all elderly and young women in whom there is marked organic heart disease, diabetes mellitus, chronic nephritis, lung disease, and goiter with cardiac symptoms; (3) to all patients beyond the age of forty in whom there is no contra-indication to the treatment. The older the patient and the nearer she has approched the menopause, the prompter and more satisfactory will be the result. Pfahler regards the *x*-ray as contra-indicated: (1) In all cases of myomata where the tumor is pedunculated or can be excised without destroying the reproductive powers of the patient; (2) in cases where the tumor has undergone malignant degeneration, or become gangrenous or infected; (3) in tumors associated with disease of the adnexa; (4) in those that are producing such marked symptoms that the patient is endangered more by waiting two or three months for results of roentgen therapy, than by results of an operation.

Runge, Veit and von Franque regard irradiation as most fortunately applied in intramural and submucous tumors in the absence of malignancy but unfortunate where the growth has become incarcerated or where pressure with necrosis or suppuration exists. Haenisch secured best results in patients from forty to fifty years old and deems the *x*-ray inadvisable in submucous, pedunculated, softened or infected tumors. It should be carefully employed in anemia but avoided where there is a history of preceding peritonitis or adnexal disease. In formulating practically the same indications and contra-indications Heimann warns that a microscopic examination of curetted material should always be made before instituting irradiation, even where malignancy is not particularly anticipated. This method of procedure has been employed by Krönig and Gauss, so that no malignant cases would be rayed. They also avoid *x*-ray treatment in fibroids of the cervix in marked metrorrhagia and suspected sarcomatous change, and in tumors complicated by acute incarceration of the bladder.

Kupferberg would exclude roentgenotherapy in all young women wherever possible, as well as in all pedunculated tumors, whether submucous or subserous. Pfender has found it especially valuable in cases accompanied by marked anemia, myocarditic or renal and other diseases which would endanger the patient's life if subjected to surgical treatment. In Stern's opinion all uncomplicated cases of uterine fibroids are amenable to irradiation, the nearer the patient being to the climacteric, the surer and speedier the results. In young women, where temporary amenorrhea with reëstablishment of menstruation is expected, fractional dosage is preferable to the massive dose. A constant and definite contra-indication to *x*-ray application is pregnancy.

Radium or mesothorium has been used most extensively by Kelly, Abbe, Cheron, Pinkuss and Gauss. The cervix is dilated and an amount of radium varying according to the size of the tumor and the thickness of the adjacent tissues is placed within the uterine cavity. It is inclosed in a tube and properly screened. Where the effect

of the ultrapenetrating rays only is desired, a further wrapping of several folds of gauze is added. Kelly prefers a large dose with short exposure, the ideal being 0.5 gram of radium element for two hours. Treatments are continued at regular intervals over periods of two months to eighteen months. Cheron employs 5 cg. of radium and each sitting lasts from six to twelve hours or even longer. In large tumors an additional massive dose is given through the abdominal wall with the hard tube.

The indications and contra-indications for the use of radium are about the same as for the *x*-ray, except that even submucous and subserous pedunculated tumors seem to yield to its influence. Results are more speedily obtained and more permanent, and the effect on the ovary seems to be less marked, even where complete amenorrhea is produced. Of 36 cases treated by Kelly operation was required in 1 only. The tumors decreased in size or disappeared regardless of their original size or kind. In 50 per cent. of his cases there were no menopause symptoms and in most of the others this reaction was mild. The series treated by Gauss included even tumors of the cervix and those complicated by adnexal disease, regardless of age or degree of anemia. All tumors disappeared but one and this one decreased one-half in size. Excessive bleeding ceased at once and amenorrhea persisted after six months.

The results of radiation by the *x*-ray alone are shown in several interesting series of cases. Runge reported 90 cases so treated, 86 of which become amenorrheic, 4 requiring operation later. Forty per cent. of the tumors showed decrease in size. Of Firth's series, 80 per cent. were cured symptomatically, 5 per cent. were improved, 15 per cent. were not benefited. Langes had 1 failure out of 15 cases. Ebeler treated 21 cases of myomata, with amenorrhea in 76 per cent., oligomenorrhea in 10 per cent., and failure in 14 per cent. In Pfahler's series of cases, 75 per cent. of the tumors disappeared: He makes the point that the success attained is greater in proportion to the dose of radiation applied to the surface of the body, as well as to its penetrating power and its filtration. Haenisch treated 31 cases, 24 being cured and 3 improved, with decrease in size of the tumors. Fraenkel claims good results in two-thirds of 280 myomata. Kähler reported amenorrhea in 50 per cent. of 26 fibroids, and improvement in the rest. Thirty per cent. of the tumors showed a decrease in size. Levy-Dorn found that the fibroids atrophied even where hemorrhage did not cease, or where it returned after cessation. Béclère's series consisted of 71 cases, with marked decrease in the size of the growths and the appearance of menopause in all but two. His cases, however, were from thirty-nine to fifty years of age. Pirie had 50 cases, all but 2 of which decreased in size and ceased bleeding. Von Graff had 31 cases cured out of a total of 36; Kreuzfuchs, 26 out of 29 cases; Reifferscheid, 31 out of 49 cases, with 4 others improved; and von Seuffert, 22 out of a total of 23. Stern succeeded in securing permanent amenorrhea in every case where the patient was over forty years of age. His

series consisted of 21 cases, in 2 of which normal pregnancy and labor subsequently ensued.

In the early years of its application to uterine hemorrhages certain unfortunate results were observed due to the *x*-rays. Soon after radiation patients complained of dizziness, with marked anemia on leaving bed at the end of treatment, vomiting and vesical tenesmus. The sudden onset of menopause symptoms after massive dosage was at times very annoying. Injuries to the bladder and rectum, and to the small intestine were reported. Burns of the skin were frequent and occasionally of the vagina. Occasionally a patient would collapse. Certain clinicians, Fränkel and Haenisch among them, warn against the use of enormously high doses in order to avoid such disturbances. The expert roentgenologist, however, has found that by proper adjustment of his apparatus to individual conditions and by adequate screens and filters, the patient may be safeguarded from the more severe reactions. The anemic woman should be kept in bed during treatment and the extremely fat one particularly guarded against skin burns.

As yet it is too early in our experience to pass judgment on the value of radium emanations in fibroid tumors of the uterus. Thus far it appears to constitute our best palliative measure, though, as has been indicated numerous clinicians have already reported series of "cures." It should be carefully borne in mind, however, that symptomatic cures are often far removed from anatomical ones, and without doubt the next five years will show a large number of recurrences, pathology reasserting itself with the restoration of functional activity in the organs involved. The controversy between the advocate of roentgenology and the surgeon hinges on the fact that so large a proportion of fibroid tumors are subject to benign or malignant changes. Thus Tracy calls attention to a series of 3561 cases collected some years ago, of which 1189 cases, 33.3 per cent., showed degenerative changes in the tumor and uterus, or in the tubes, ovaries and broad ligament of such a nature as to preclude cure by *x*-ray. Malignancy was present in 4 per cent. of these cases. It is pointed out that the mortality from operative treatment is not above 2 per cent. or 3 per cent. at the most, and that the very complications which contra-indicate irradiation are the ones which cause operative mortality. If these were eliminated from surgical statistics, no comparisons between the two methods of treatment would be possible. The best indications for *x*-ray on this basis are, according to Frank, as follows: (1) When operation is absolutely declined; (2) in patients with severe heart disease or grave nephritis who are bad operative risks; (3) in a very small group in whom the physical trauma of operation must be avoided at all costs. Tracy would limit irradiation: (1) To patients with marked anemia to control bleeding until restoration to strength sufficient for operation; (2) to patients who continue to bleed after myomectomy, the specimen showing no malignancy; (3) to patients whose general health is so poor as to contra-indicate operation. To these limited indications McGlinn would add such systemic conditions as advanced tuberculosis, diabetes and syphilis.

In the last analysis possible in the light of today's experience it is evident that surgery is limited only by the condition of the patient while *x*-ray and radium are limited by the condition of the tumor itself. It is, therefore, altogether beside the mark to compare the total surgical mortality with the immediate results of irradiation. Time alone will show how many fibroids symptomatically cured will recur, or how many will cause death through unrecognized malignancy.

Surgical Treatment.—1. **Vaginal Route.** (*a*) *Curettage.*—This procedure, as an operation *per se*, has disappeared. While the operative mortality of uterine fibroids was high it was effective in temporarily checking hemorrhage in some cases. Until a few years ago curettage occupied a similar position as a palliative measure until the patient's condition could be restored sufficiently to warrant radical operation. But since roentgenotherapy has been developed as a means, primarily, of checking hemorrhage, the removal of its mucous lining from the uterine cavity has become unnecessary and unwise. Today curettage in uterine myomata has but one definite purpose, though here a valuable one, viz., to secure material for microscopic examination. This pre-operative attempt at diagnosticating malignancy has been emphasized of late by the roentgenologist, who has assumed responsibility for the final cure of fibroids, whereas the surgeon has been somewhat to prone, perhaps, to leave the recognition of such changes in the tumors to the pathologist in his laboratory.

The editor has found that his patients who have had preliminary curettements for the purpose of making a microscopic diagnosis, invariably died of metastatic growth, in case carcinoma was found to be present, provided the curettement was made several days before the final operation was executed. In case the curettement was made immediately before the hysterectomy was performed, a positive diagnosis was possible only in cases in which this diagnosis could readily have been made without the curettement and without the use of the microscope. In case a negative diagnosis was made, it has never seemed proper to accept this as final in any case in which there was the slightest doubt after the physical examination. Consequently, it seems that the small amount of good that the patient can gain from the microscopic examination cannot compensate for the risk she runs of having the malignant growth disseminated.

(*b*) *Ligation of Vessels.*—This procedure is now of historical interest only and has been supplanted by more effective palliative or operative measures. It was an easily applied and satisfactory means of checking hemorrhage in the early days of pelvic surgery, when hysterectomy was attended by a mortality varying from 5 to 20 per cent. In 1893 the writer described a somewhat original method of performing this ligation, whereby not only the uterine arteries but the entire base of the broad ligaments were tied off, thus occluding the main arterial channel, and its collateral branches as well. In occasional cases this ligation was carried high enough on one side to take in the ovarian artery.

(*c*) *Removal of Pedunculated Subserous Tumors.*—Pedunculated submucous fibroids may be completely removed through the dilated cervix without interfering materially with the uterus. Unless the tendency to pediculation is well established, however, and the center of development comprising the tumor is the only center of fibroid development to be discovered in the walls of the uterus, as shown by careful bimanual palpation, it should be treated by hysterectomy, either vaginal or abdominal.

The removal of the intra-uterine pedunculated fibroid is usually a simple procedure. If the pedicle is small and long, and the tumor in

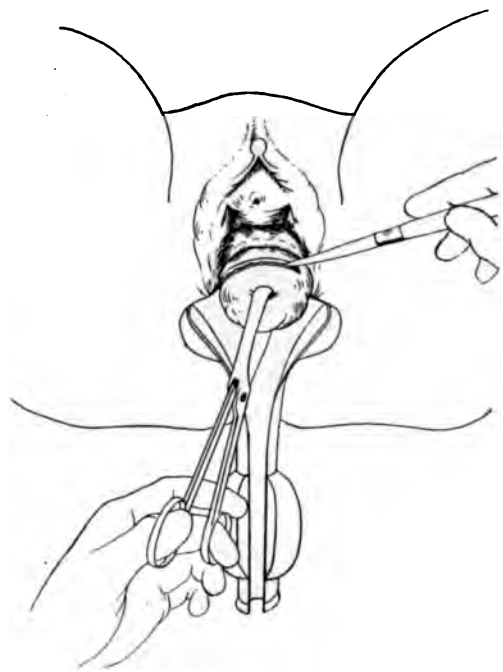


FIG. 198.—Extirpation of a submucous pedunculated myoma by enucleation. Incising the capsule of the tumor. (After Berkeley and Bonney.)

a position where it can be reached easily it is grasped by a vulsellum and twisted until the pedicle is actually broken. This can be done only with thin pedicles. If the pedicle is broad the uterus should be sufficiently dilated, the patient being under an anesthetic, to expose the pedicle; if it is necessary, in order to accomplish this, the cervix may be divided as high as the vaginal junction. The mucous membrane of the pedicle should next be cut in its entire circumference. Then the remaining portion of the pedicle, composed of the blood-vessels, connective and muscular tissue, should be twisted in the same way that one proceeds to twist off a small pedicle. If the remaining portion of the pedicle is small it will give way to this treatment. If it

is rather large and fleshy, after twisting it into a small bulk, it may be grasped by a strong pair of curved pedicle forceps and the pedicle severed with scissors or a knife outside the forceps. If the pedicle is very vascular the forceps may be left in place for six or twelve hours. If this does not seem necessary the forceps should be removed and the uterus packed with gauze. If the forceps are left on the pedicle, gauze should be packed around them. The forceps may be removed in six or twelve hours without disturbing the gauze.

It is unwise to attempt to enucleate a submucous fibroid of any considerable size if its principal bulk is buried in the walls of the uterus.

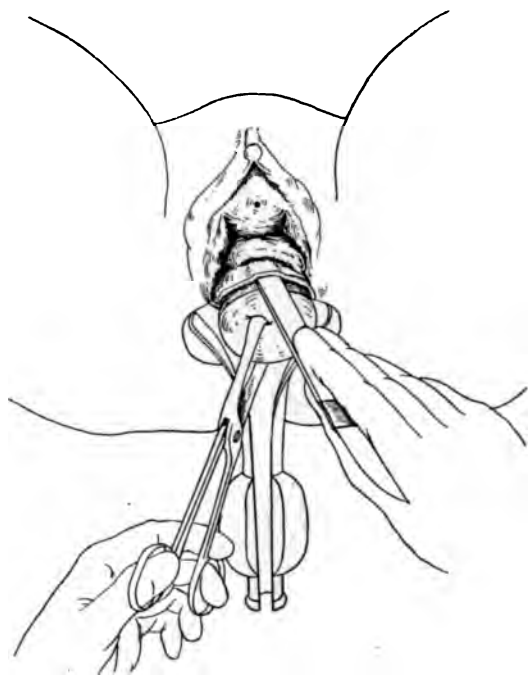


FIG. 199.—Extirpation of a submucous pedunculated myoma by enucleation. Reflecting the capsule of the tumor with the scalpel handle. (After Berkeley and Bonney.)

Such a procedure is attended with considerable mechanical difficulty because of the position of the tumor in the cavity of the uterus; it is also difficult to secure hemostasis in such a location and, finally, in such a procedure one seldom reaches more than one of several centers of development in the uterus. In these cases a hysterectomy is more satisfactory.

A cervical fibroid developing beneath the mucous membrane, if pedunculated, should be enucleated in the same manner as that described for removing a pedunculated intra-uterine fibroid.

(*d*) *Myomectomy.*—Occasionally tumors occupy the cavity of the uterus, and when they have reached the mucous membrane and are

producing a distinct bulging of the surface of the uterine canal, myomectomy may offer a means of cure of the condition. Obviously if the uterus, as found on palpation, is the seat of a number of centers of development, it is better in all cases to do a hysterectomy, in order to accomplish a complete cure. If, however, but one or two centers of development are found projecting into the mucous membrane, and bimanual palpation does not demonstrate tumors which cannot be removed by enucleation from the canal, then vaginal myomectomy may be resorted to.

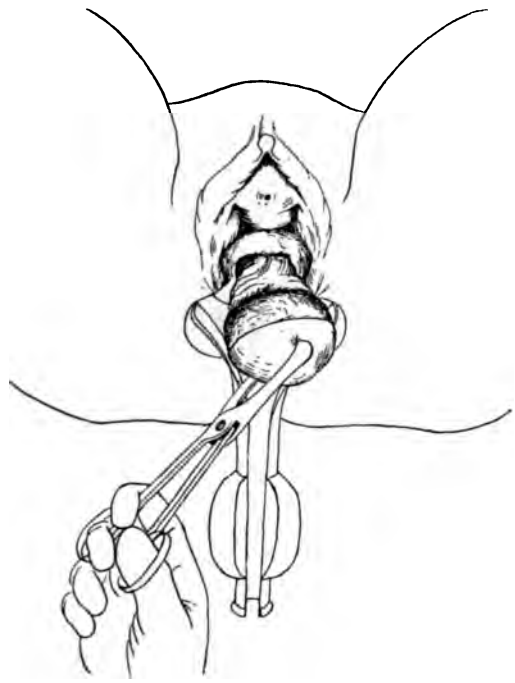


FIG. 200.—Extirpation of a submucous pedunculated myoma by enucleation. The tumor freed and ready to be cut from its pedicle. (After Berkeley and Bonney.)

The method of procedure is as follows: The patient is placed upon her back in the exaggerated lithotomy position, two wide retractors are inserted and held by competent assistants, the uterus is drawn well down, its canal thoroughly divulsed with Goodell's dilators and the projecting tumor exposed. The uterine cavity is first well swabbed with tincture of iodine but is not curetted. In such cases curettement cannot be thorough owing to the tortuosity of the cavity; it does not prevent the mucosa from regenerating as it was before; it opens up numerous avenues for infection which otherwise would remain closed. The tumor is then grasped by a vulsellum forceps and held taut while the operator severs the mucous membrane over the side of the tumor until it is seen that the capsule has been opened. The parts are then

separated by blunt dissection, which is carried on until the growth is entirely enucleated. If the canal is too small to admit of the delivery of the tumor intact, it may be removed in pieces, or by *morcellement*. In such cases it may be difficult to close the opening of the cavity from which the tumor is removed. No great amount of time should be spent in making an effort to do so, as the cavities may be packed with gauze. This is to be removed in two or three days, by which time the uterus will be thoroughly contracted and the cavities obliterated. If there are several centers of development the same procedure should be carried out for all.

FIG. 201.—Extirpation of a submucous pedunculated myoma by enucleation. The twisted pedicle is cut through high up in the cervical canal. (After Berkeley and Bonney.)

In the cervix a tumor of small size may be excised by splitting its capsule, grasping the tumor with a vulsellum, and dissecting it from its bed. If large, its removal is carried out by morcellation, small portions such as may be exposed being cut out in cone-shaped pieces one at a time. The tumor cavity may be closed with catgut sutures or it may be packed with gauze. This operation may be attended by profuse hemorrhage, and, unless vaginal exposure is adequate, closure of the cavity may be difficult.

Where a small myoma is situated in the vaginal portion of the cervix it is best removed by a high amputation of the cervix. The vaginal

vault is opened by a circular incision just above the portio and lateral ligatures are placed and tied and the tissues cut close to the cervical wall. The folds of vaginal mucous membrane are then stripped up anteriorly and posteriorly, care being taken to avoid wounding the bladder. Laterally ligatures are placed and the tissue cut until the tumor is isolated. The cervix is then cut across and the wound repaired exactly as in amputation for cervical laceration. In large tumors in this situation morcellation will again be necessary owing to difficulty in exposure through the relatively narrow vaginal canal. Where the vagina is too narrow to permit proper manipulation a Schuchardt incision becomes necessary.

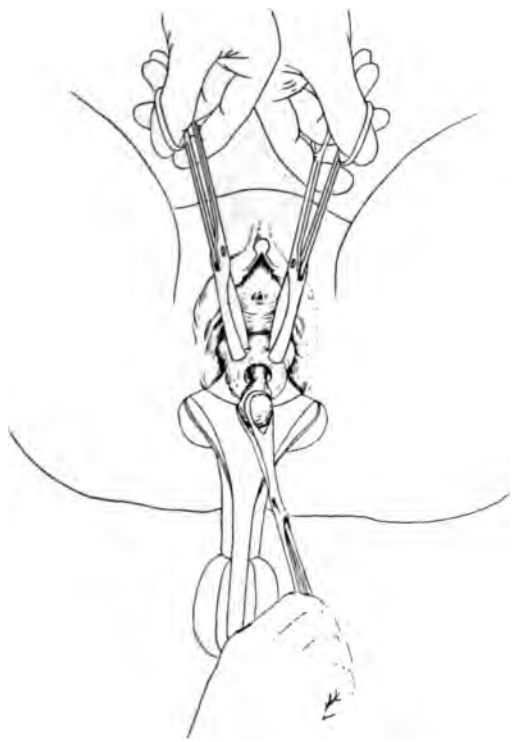


FIG. 202.—Extirpation of a small fibroid polypus. (After Berkeley and Bonney.)

(*e*) *Vaginal Hysterectomy.*—In small tumors where one may be reasonably sure that no dense adhesions exist, removal of the uterus by the vaginal route is a satisfactory procedure. In order to accomplish this, the vagina is exposed by a hanging speculum posteriorly and two lateral and one anterior retractors. The cervix is then seized by a vulsellum placed in its anterior lip and drawn down as far as possible. A second vulsellum is then placed in the posterior lip, the two being held together as a single tractor. Or the vulsella may be made to seize both lips together, thus closing the external os during the time of

the operation. With the cervix then drawn well out a circular incision is made entirely about it just above the portio, going entirely through the mucous membrane and its underlying cellular tissue. With a double layer of gauze on the forefinger the mucosa is now stripped up a short distance anteriorly and posteriorly, aided as may be necessary by the scissors or scalpel. This leaves the vaginal wall attached laterally by a narrow band of somewhat denser tissue. With a large pedicle needle a heavy catgut ligature is now passed on either side and tied so that the knots lie close to the edge of the cut vaginal wall. These lateral bands are now severed by cutting between the cervical walls and the ligatures, leaving sufficient tissue to form stumps.

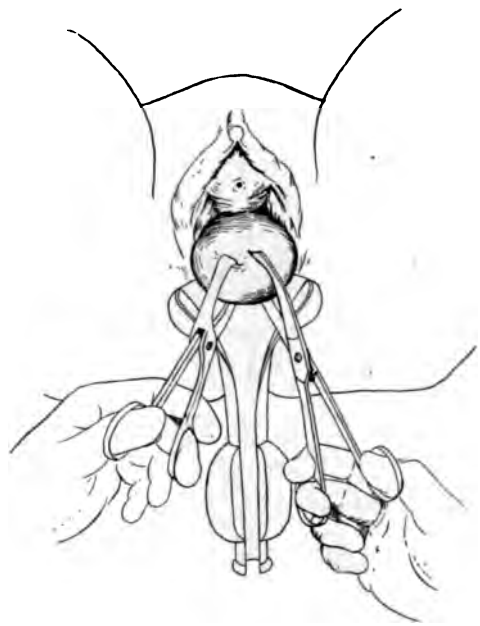


FIG. 203.—Extirpation of a submucous myoma by morcellation. Cutting away the lower pole of the tumor. (After Berkeley and Bonney.)

The free ends of the two ligatures are then cut short, since these are placed merely to control bleeding from the vaginal walls. These are the only ligatures that are cut short, all the rest being left long and held in forceps. The base of the bladder is now exposed and this is stripped free by the finger tip from the anterior cervical wall, the dissection passing upward and to either side until the anterior peritoneal fold can be reached. The same maneuver frees the cervix posteriorly. This leaves the lower portion of the broad ligaments well exposed laterally. These are now ligated with catgut ligatures as before, first on one side, then on the other, extreme care being taken to avoid the bladder and ureters. These latter lie parallel with the uterine wall, as the uterus is drawn down, hence the ligatures must

be laid close against the cervix. The tissues are then cut as before, between the uterine wall and the ligatures. As the tissues are severed each time the uterus becomes freer and can be brought down further and further. By the time that the uterine arteries have been ligated and severed the posterior cul-de-sac is exposed. This is now cut into, the free peritoneal edge being incised well around to each side. It is better at this time to stitch this free edge to the vaginal mucosa in the midline posteriorly by an over-and-over catgut suture. This prevents the peritoneum from retracting up into the pelvis and renders peritonization easier at the close of the operation.

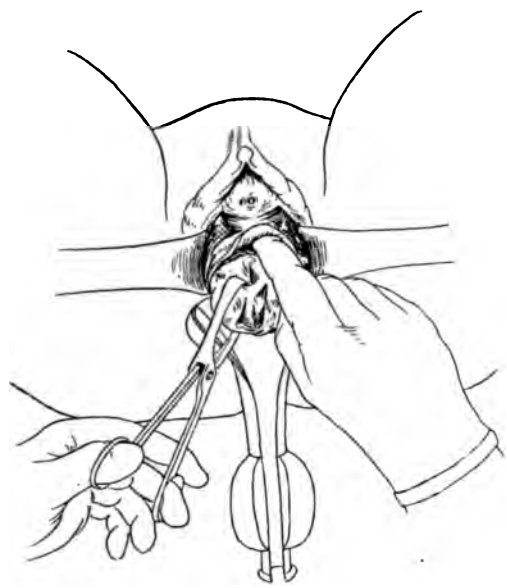


FIG. 204.—Extirpation of a submucous myoma by morcellation. Reflecting the capsule of the tumor with the finger. (After Berkeley and Bonney.)

The next step is to open the anterior cul-de-sac. To be absolutely certain that the bladder is entirely separated from the uterus a sound may be passed into it, though this is not often necessary. However, it is wiser in every case to place a retractor beneath the bladder, thus raising it up behind the symphysis pubis and exposing the anterior peritoneal fold. With a knife or scissors this is now opened, the incision being carried from one side to the other close against the uterus. The free edge of the peritoneum is then stitched to the anterior vaginal mucosa, as was previously done posteriorly. By the time the uterus is quite free, being attached only by the two pedicles formed by the round ligaments and appendages on either side. These are now ligated separately or *en masse* and the uterus cut entirely away. The writer favors separate ligature of the round ligaments, tubes and ovarian arteries, not only for the sake of greater security but in order to hold the structures separately into the wound in closure.

As soon as either the posterior or anterior peritoneal folds are opened a small gauze pack is introduced, to prevent intestinal or omental prolapse. This is now withdrawn and preparation to close is made. Moderate traction on the ligatures, which have been left purposely uncut, will bring the broad and round ligaments and the tubes well down into the vaginal vault. Here they are firmly sewn with heavy catgut on a needle by over-and-over interrupted sutures, closure of the vaginal vault being effected at the same time. Since the cut peritoneal edges already have been attached to the vaginal

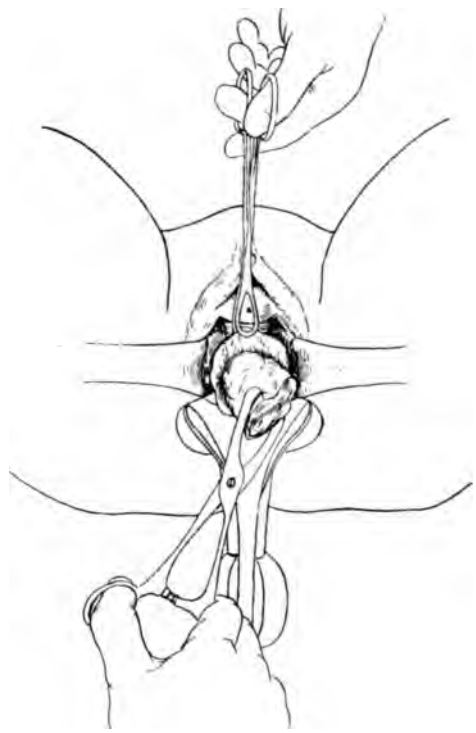


FIG. 205.—Extirpation of a submucous myoma by morcellation. Enucleation of the upper pole of the tumor. (After Berkeley and Bonney.)

mucosa, the interior of the pelvis is thus peritonized. The operation is finished by cutting the free ends of the ligatures and loosely packing the vagina with gauze.

The operation for vaginal hysterectomy, as described here, may be modified in a variety of ways. Where it is desired to remove the appendages as well, the uterus is drawn well out from between the vulva after the broad ligament has been severed. This brings into exposure the tubes and ovaries, so that the infundibulo-pelvic ligaments may be readily reached. Ligatures are placed through these and tied and the ligaments are then cut, the incision being carried down

beneath the tubes to the round ligaments, exactly as in the enucleation of these same structures by the abdominal route.

In a fairly large proportion of cases hysterectomy is technically simplified by reversing the position of the uterus as soon as the anterior and posterior peritoneal folds have been opened. To do this the finger is inserted into the anterior cul-de-sac and the fundus uteri is pulled forward until it can be grasped by a vulsellum. By pulling forward on it and at the same time thrusting the cervix back into the posterior vaginal vault, the corpus may be delivered beneath the symphysis pubis. This maneuver enables the operator to carry on the rest of the enucleation from above downward, as in abdominal hysterectomy.

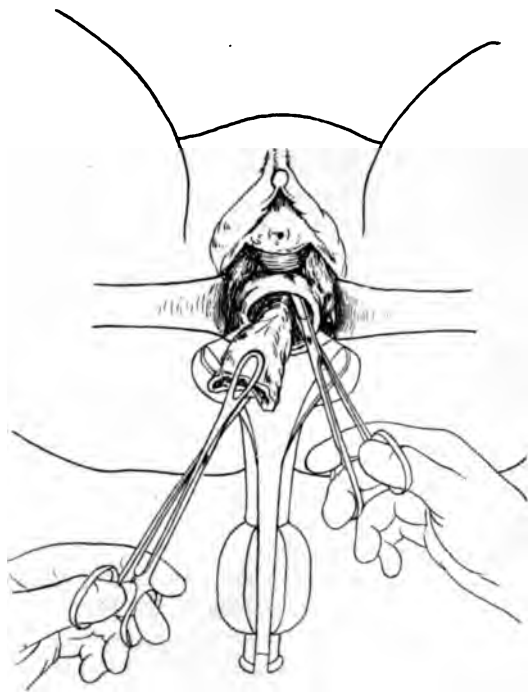


FIG. 206.—Extripation of a submucous myoma by morcellation. Treatment of the capsule of the tumor. (After Berkeley and Bonney.)

Doederlein's procedure of splitting the uterus mesially is of great advantage in vaginal hysterectomy, especially where the organ is enlarged or asymmetrical, as is the case even in small myomata. As soon as the cervix is well exposed, the posterior wall of the cervix and corpus is split in the median line from below upward and then the anterior wall in the opposite direction. This enables the two halves of the uterus to be drawn well apart, thus yielding exposure and enabling the operator to ligate and sever the tissues again from above downward, always a technical advantage. It is necessary here to be extremely careful in order to avoid wounding the bladder and rectum.

In larger fibroids of the uterus vaginal hysterectomy is apt to present obstacles, if not insurmountable, at least sufficiently serious to make abdominal enucleation far preferable. In rare instances, however, it may seem wiser to attempt removal of the tumor from below. Here the cervix is exposed as before and the anterior and posterior pouches opened freely. With the bladder well retracted behind the symphysis, as much as possible of the enlarged uterus is exposed through the vaginal orifice. This exposed portion is seized by a long-toothed vulsellum, or by Sims' fibroid auger, and drawn down as far as possible. With a double-edged knife a cone-shaped section of the mass is excised, cutting out the vulsellum with its attached tissues. The tumor is then shifted and another portion similarly excised. This process of morcellation is continued until the entire tumor mass has been removed. When nothing but the lateral walls of the uterus remains ligation and resection is proceeded with as already described.

Hysterectomy by the vaginal route is apt to be without difficulty in the multipara, where the vaginal walls are elastic or relaxed. In the primipara, on the other hand, and, most of all, in case of senile constriction, or where the uterus is enlarged and hard or adherent, the operation is usually attended with serious difficulty. In such cases it becomes necessary to enlarge the vaginal introitus by a unilateral Schuchardt incision. By means of this most of the difficulties are overcome. Where, however, in spite of all the operation bids fair to become a surgical struggle, abdominal hysterectomy should be the operation of choice.

2. **Abdominal Route.** (*a*) *Ligation of Vessels.*—But a few years ago, before modern surgical technic had made hysterectomy a safe operation, ligation of the ovarian arteries was the operation of selection for the relief of uterine fibroids, when as severe an undertaking as a laparotomy was deemed necessary. At present it is rarely performed, except as a last resort, when laparotomy has been performed with the object of removing the tumor and uterus, and when, because of contraindications, the latter operation is found inadvisable. In former days ligation of the ovarian arteries only was attempted, depriving the uterus of about one-third of its blood-supply. Today ligation of the uterine arteries also would be performed.

(*b*) *Oöphorectomy.*—This procedure, like the preceding, has come to be of historical interest only. It still may be advised for certain cases in which, for some cause, such as extensive growth into the broad ligament, there arises exceptional difficulty in removing the uterine body, while the ovaries may be readily extirpated. Such cases are rare. Oöphorectomy stops uterine bleeding by requiring ligation of the ovarian arteries and by removing the hormone which activates the uterine mucosa. While the former desirable result is not always brought about, the latter inevitably comes to pass, with its attendant menopause reaction. As has already been explained, the results sought for by both arterial ligation and ovarian extirpation is now more readily obtained by radium emanation.

(*c*) *Abdominal Myomectomy.*—Myomectomy, or removal of fibroids from the walls of the uterus, is an operation which has a considerable following, but which in the writer's opinion should be reserved for a small percentage of cases. The operation consists in exposing the tumor through an abdominal incision and enucleating it from its capsule without severing the muscular tissue of the uterus covering it, and then enucleating it from its surroundings. Where there are one, two or three centers of development, which are very close to the surface of the uterus, and which have begun to pedunculate, the operation is very simple, and appeals to one as a rational procedure. But if the tumors are located deeper in the tissues and if they are multitudinous in number, the operation is more difficult of accomplishment, and many times it becomes absolutely impossible to remove all the deeper centers. Under such circumstances myomectomy is unjustifiable: (1) Because of the danger of the operation; (2) because of inability to remove many of the deeper centers of development and hence the operation will prove inefficient.

The operation should be performed in the following way: The uterus is brought well up into the abdominal wound, an incision is made over the portion of the tumor which appears to lie closest to the surface of the uterus and in a direction parallel to the bloodvessels in the immediate vicinity. After severing the capsule of the tumor the fibroid is grasped with a strong vulsellum and by means of the fingers, or a Kocher's director, the tumor is rapidly enucleated from its shell. Any bleeding points of consequence are grasped with forceps and the cavity temporarily packed with gauze. Other centers of development are attacked in the same way and the tumors are removed. A search is then made by palpating the entire mass to discover other nodules and when one is satisfied that all centers have been removed, or all that it seems advisable to remove, the different cavities are inspected and, if necessary, any important bleeding-points are tied. In case the hemorrhage is excessive from all surfaces and the tumors are located in the upper portion of the uterus, the ovarian arteries may be tied at the point where they enter the broad ligament, and thus a large portion of the blood supply to the fundus of the uterus will be cut off and hemostasis secured.

The cavities are then closed with buried catgut sutures in such a way as to approximate their surfaces and leave no dead spaces for the accumulation of fluid. It is important to guard against pressure necrosis apt to be induced by drawing these stitches too tightly. Finally the peritoneum is closed over the surface with a running catgut suture.

(*d*) *Abdominal Hysterectomy.*—Dr. Gilman Kimball, of Lowell, Mass., was the first to deliberately plan and execute an abdominal hysterectomy for fibroids of the uterus. The operation was performed in August, 1853. On June 25 of that year Dr. Walter Burnham, of the same city, removed a portion of the uterus for this disease. Ten years later, December, 1863, Koeberle did his first hysterectomy

for fibroids, with external fixation of the stump of the uterus. He employed a metallic ligature with a special device for tightening it. Péan soon followed Koeberle, supplementing the latter's work by the free employment of forcipressure, and, by publishing a systematic technic which included the employment of steel pedicle pins over the metallic ligature for maintaining the pedicle extra-abdominally, his name became inseparably associated with hysterectomy by the extraperitoneal method. Dr. M. M. Latta, of Goshen, Ind., completed an abdominal hysterectomy by tying the broad ligaments in sections down to the vagina, July 6, 1876. The elastic ligature for temporary ligation was first employed by Kleeberg, of Odessa, July 8, 1878. In August, 1878, Martin recommended the provisional elastic ligature. Hegar, about the same time, recommended the elastic ligature for permanent intra-abdominal ligation of the pedicle.

In the evolution of abdominal hysterectomy many methods have been adopted, and at different times each has had its advocates. The yearning for perfection has made confusion, owing to great efforts in many directions. In the early history of the operation the best results came with the extraperitoneal methods of treating the stump. Within recent years, with improved technic, and greater experience, the pendulum has swung irresistibly toward the intra-abdominal pedicle.

In referring to the different methods which were developed in the evolution of abdominal hysterectomy, it is unnecessary to dwell particularly upon the various procedures. Each had its place, and in emergencies the different methods may occasionally be resorted to with advantage, but the final outcome is represented by that method in which the arteries are ligated outside of the uterine tissue, making it possible to employ safely an intraperitoneal amputation. This method properly consists in ligating the ovarian artery with or without the broad ligament; severing the broad ligament, after placing hemostatic clamps on the uterine side down to the uterine arteries; ligation of the uterine arteries; severing the uterus at the cervix; cauterizing the cervical canal; closing the stump; burying the pedicle with peritoneum, making the stump practically extraperitoneal instead of intraperitoneal; closing the broad ligament with a running stitch of catgut; and closing the abdominal wall.

Indications for Hysterectomy for Fibroids.—The removal of the uterus containing in its walls a uterine fibroid is the only absolute cure for this benign neoplasm. Ligation of the arteries supplying the uterus, with its tumors, may deprive the growth of an excess of nutrition and cause it to atrophy; it may reduce many of the severe symptoms under which patients labor with this difficulty; the employment of electricity likewise may relieve the patients symptomatically; the removal of the uterine appendages will cause an artificial menopause and relieve the excessive hemorrhage; the value of radium and *x*-ray is not yet definitely estimated and has been discussed; but the only procedure which will absolutely cure the difficulty is one which will

eradicate the tumor and the tissues in which the tumor is located, viz., the uterus.

Notwithstanding the enormous advance in abdominal surgery and the gradual reduction of the death-rate in abdominal surgery for fibroids from 40 to 2 per cent. the writer is inclined to agree with those surgeons who do not demand that all women having uterine fibroids should submit to operation. A patient with a small fibroid, who has lived to the age of forty or forty-five years, and who has not been inconvenienced by a deforming tumor or by symptoms such as hemorrhage and pressure, and whose general health has remained robust, need not of necessity, be subjected to an abdominal hysterectomy. Such a case will very frequently continue without severe symptoms until the menopause supervenes, and the atrophy of the uterus coincident with the menopause will cause a reduction in the size of the tumor and prevent the development of distressing symptoms. The decision as to operation should be left to the patient and her people, after the conditions *pro* and *con* have been fairly presented. The strongest argument in favor of operation lies in the increasing chance of degeneration with advancing years.

Fibroids, however, of small size, which show a tendency to grow and which give rise to distressing symptoms of pressure or hemorrhage in women of forty years of age or under, or where the general health tends to fail after that age, should be submitted to a radical operation for their removal—either a vaginal or an abdominal hysterectomy.

While this will indicate the minimum indications which should call for hysterectomy, on the other hand no fibroid tumor at this time should be considered too large or too complicated to warrant an abdominal hysterectomy. In the last few years the operation has been perfected to such a degree and from every standpoint, that few surgeons of experience would now hesitate to undertake, with the expectation of success, any case of fibroid tumor of the uterus.

The burying of the tumor in the broad ligament, its growth beneath the peritoneum in different directions, its adhesion to the surrounding tissue, are complications which are now dealt with so successfully that they really have little terror for the experienced surgeon. One condition which makes the surgeon hesitate in the radical operation for these cases lies in that very small percentage of cases which have been neglected for long years, until the patient is reduced to a very low state of anemia. Even in these, however, where the anemia is caused by great blood loss, the tumor may be removed expeditiously and the patient immediately placed in a condition in which perfect hemostasis is secured and blood loss can no longer cause depletion. The writer has frequently operated upon cases with the percentage of hemoglobin under 20 or 30 per cent. with perfect success. Furthermore, with modern hospital management and the use of the *x*-ray, such cases can be controlled until the hemoglobin has been increased and the patient's vitality largely restored.

Subtotal Hysterectomy.—*Opening the Abdomen.*—The abdominal incision for an abdominal hysterectomy should obviously be made with

the idea of allowing plenty of room for the delivery of the tumor as it has appeared in the mind's eye of the surgeon in diagnosing the case. The incision should be carried from a point below the umbilicus to a point well down to the symphysis. Where the tumor is of the larger abdominal variety this opening may later be carried above the umbilicus. The first incision should be carried to the aponeurosis of the muscles through the entire length of the contemplated final opening. The aponeuroses should be then separated well down to the lower end of the superficial wound. In doing so the recti muscles may be freed from their sheaths, thus permitting them to be approximated in closure. This is particularly important where the abdominal wall is relaxed or diastatic or where the umbilicus has been excised. The peritoneum should be opened at the upper end of the incision by grasping the subperitoneal tissue with two forceps in such a way as to elevate the peritoneum into a transverse fold. The scalpel is then made to sever the subperitoneal tissue until the peritoneum is in view. Now with a scratch of the knife the peritoneum is opened. The opening into the abdomen is made at the upper angle of the wound in order to avoid any possibility of injuring the bladder, which is frequently drawn well up upon the abdominal wall by buried fibroids. The surgeon's finger should then be introduced into the wound as a guide, and the peritoneum opened down to within an inch of the lower end of the wound, careful inspection being maintained for adhesions. It is unnecessary to go further than this, because of the elasticity of the peritoneum, which will allow it to stretch well down beneath the lower angle of the wound, and the avoidance of cutting the peritoneum below makes a wounding of the bladder less likely. Just previous to incising the peritoneum the patient should be tipped into the Trendelenburg position.

Exploration of the Abdominal Cavity.—The opening of the abdomen may be considered the first step of an abdominal hysterectomy. The next step is the exploration of the tumor. The hand of the operator should grasp the tumor and rapidly map out its contour, its different centers of development, and its relation to the other organs of the pelvis and abdomen. One glance at the tumor will indicate whether it is buried beneath the bladder or not. One sweep of the finger to either side will indicate whether it has developed beneath the broad ligament of one side or the other. Another sweep of the hand will indicate adhesions of the intestines or the omentum to any portion of the growth. And at the same time great care should be taken to ascertain whether or not the tumor has developed beneath the peritoneum at other points than in the broad ligaments.

With this general survey rapidly made the next step of the operation consists in the isolation of the tumor. Gauze pads constructed of two or more layers, six by ten inches, to the corner of which is attached a small tape six or eight inches long, should be carefully packed above and beneath the tumor in such a way as to completely wall off the omentum and the intestines from the field of operation. The small

tapes only should protrude from the abdomen, and should be clamped with small forceps. Omental and intestinal adhesions must be broken up before packing off, pelvic adhesions after.

Delivering the Tumor.—The next step in the operation is of the utmost importance and too often neglected. This consists in the attempt to deliver the tumor by grasping it at the most prominent point with one or two large vulsellum forceps. The tumor is then lifted bodily through the abdominal opening, the edges of which are

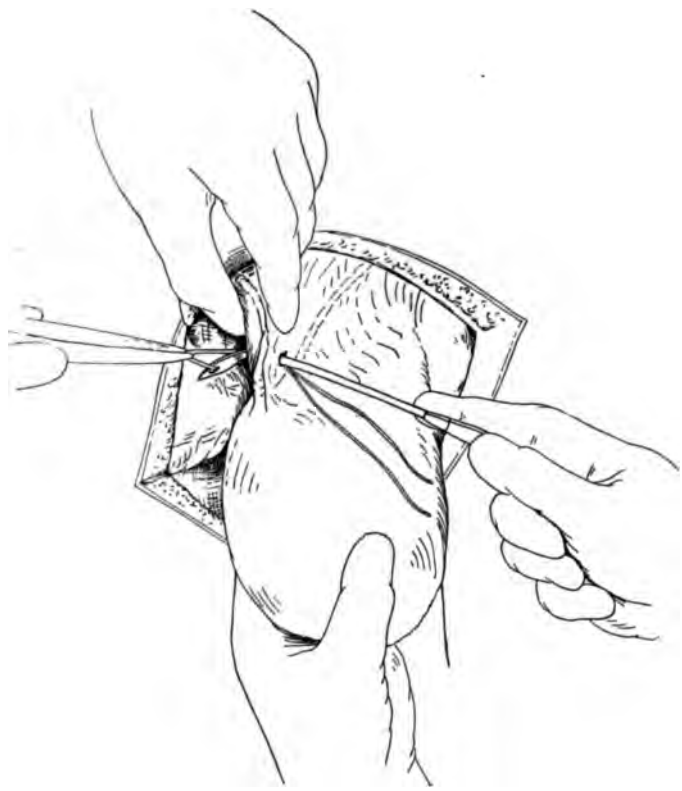


FIG. 207.—Subtotal abdominal hysterectomy. Ligature passed for tying the ovarian artery and the tube close to the uterus.

carefully stretched over the mass until it is entirely out of the abdomen, or until it shows by its resistance that soft tissues and peculiar conformation prevent its delivery. The tumor is then held firmly by an assistant while examination is made to discover the cause of the resistance. Without waiting for the completion of the other steps of the operation, if the tumor is found to be buried beneath the broad ligament and the tension of the buried portion upon these ligaments is the cause of the retention, the operator immediately splits the peritoneum over the portion of the tumor which is buried, in order to

permit its prompt enucleation. The broad ligament should be split parallel with the direction of its arteries, in order to avoid wounding these channels. Often after severing the peritoneum the tumor will suddenly yield at one or more points, in the case of different portions of the tumor projecting beneath the peritoneum, and the whole mass, including the uterus, will be delivered outside of the abdomen, with the cervix, the vagina and the remaining portion of the broad ligament as the only attached portions.

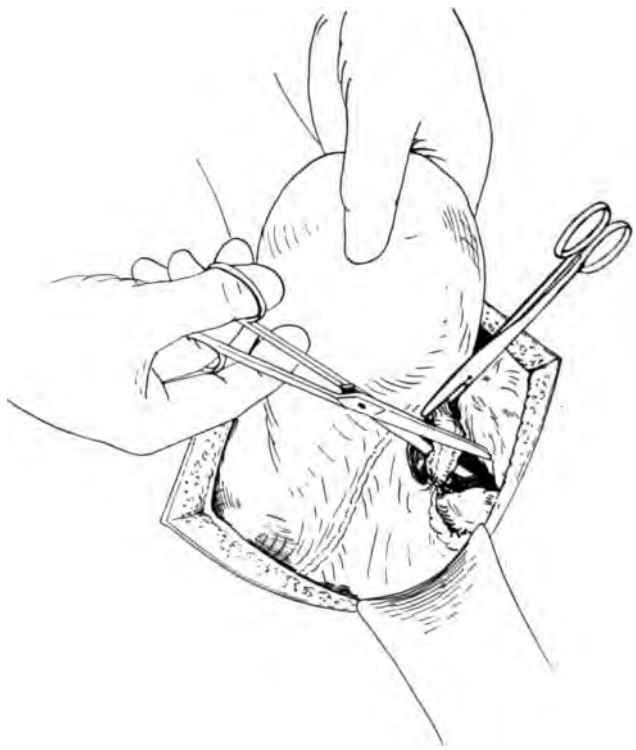


FIG. 208.—Subtotal abdominal hysterectomy. The ovarian artery and the tube ligated. A clamp placed on the uterine side. Cutting the broad ligament between.

The importance of the immediate delivery of a tumor can only be appreciated by those who have attempted to remove a large, impacted fibroid without first adopting this procedure. Without delivery of the tumor it is impossible to carry out with speed and precision the balance of the operation.

Isolation of the Tumor.—After the delivery of the tumor the next point is the ligation of the four vessels supplying the uterus and its tumors with blood, viz., the two uterine and the two ovarian arteries. With the tumor out of the abdomen the ovarian arteries should be tied at a point on the infundibulo-pelvic ligament just beyond the ovary. Catgut of good tensile strength is the best material for these ligatures,

the knot being a single one repeated three times. The sutures should be cut a quarter of an inch from the knot and a pair of forceps placed upon its uterine side to secure the collateral circulation, after which the ligament is severed obliquely inward and downward to the round ligament. No attempt should be made to include in this first ligature the round ligament but this is now tied separately close to the uterus. A forceps is again placed on the uterine side of the knot and the round ligament is cut away. The operator then, with the tumor

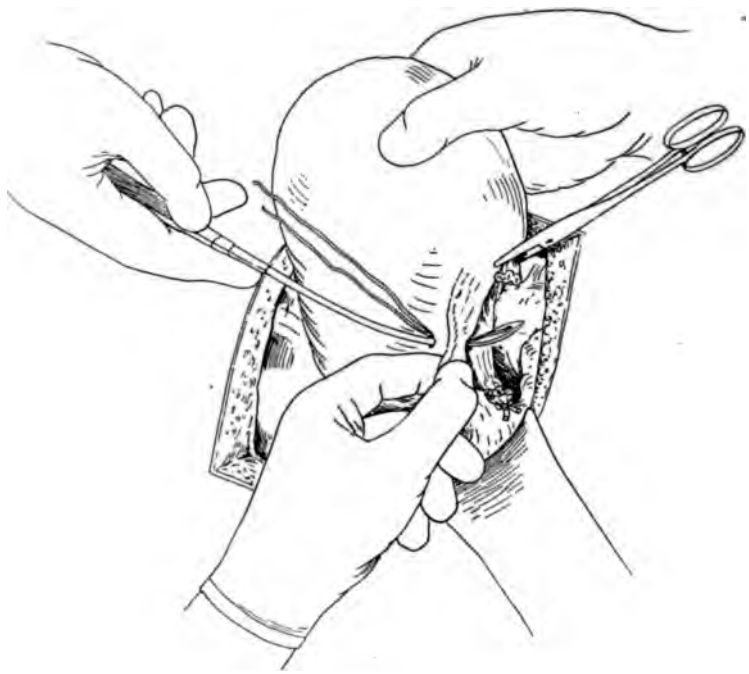


FIG. 209.—Subtotal abdominal hysterectomy. Passing the ligature to tie off the round ligament after the upper portion of the broad ligament has been severed.

drawn well to the opposite side, should seek at the base of the broad ligament for the uterine artery. This artery should be grasped with very little other tissue and the ligature carefully placed beneath it close against the wall of the cervix, tied, its uterine side grasped with another forceps, and the broad ligament severed well down to the vault of the vagina.

After each severance of the tissues between the forceps and the knots the operator should carefully sponge away any blood in order to inspect the arteries directly and thus make certain that they have been ligated and that the ligatures are holding.

The tumor is now turned to the opposite side and the uterine and ovarian arteries of that side secured in like manner.

The next step in the operation is the severance of the tumor from its attachment. If the fibroids do not involve the cervix that part

may be left as a pedicle, as by so doing the vagina is maintained in its normal length, and in its normal condition.

Removal of Tumor.—The tumor is severed in the following way:

The peritoneum at the point of its duplicature between the uterus and the bladder, in front of the tumor, is freed and the portion covering the bladder is pushed well down until the junction of the cervix and the vagina is reached. With a vulsellum forceps the cervix is grasped and held upward by an assistant so that it will not fall away as soon as the uterus is cut free. The peritoneum is then cut across posteriorly

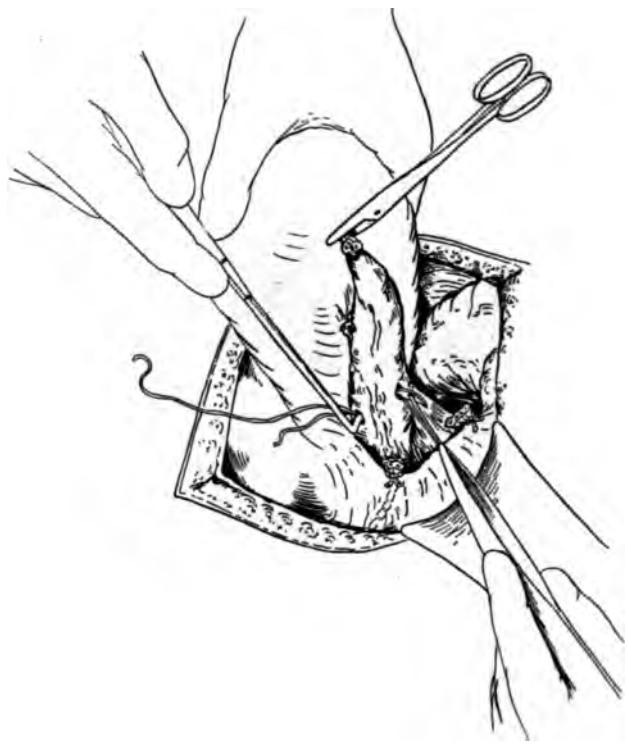


FIG. 210.—Subtotal abdominal hysterectomy. Passing the ligature for ligation of the uterine artery, the broad and round ligaments having been severed.

at the point corresponding to its severance in front. The tumor is now held well up and with a scalpel the cervix cut through by a wedge-shaped incision with the apex down.

After the removal of the tumor mass the cervical canal is swabbed with pure carbolic acid on an applicator followed by 95 per cent. alcohol. Another excellent method is to attack the cervical canal directly with the actual cautery, searing it as far down as the external os. This method is particularly effective against subsequent leucorrhea or the occurrence of malignancy.

Closing the Stump.—The cervical stump is closed by suturing with a sharp curved cervix-needle threaded with catgut. Two interrupted sutures serve to close the canal and over these a continuous suture in the outer edges causes the raw surfaces representing the wedge-shaped incision to be firmly and accurately approximated. An important feature that is omitted by many operators is now taken up. With the same needle the cut ends of the round ligaments are sewn firmly to their respective sides of the cervical stump. This procedure serves admirably to support the vaginal vault, thus preventing subsequent sagging and

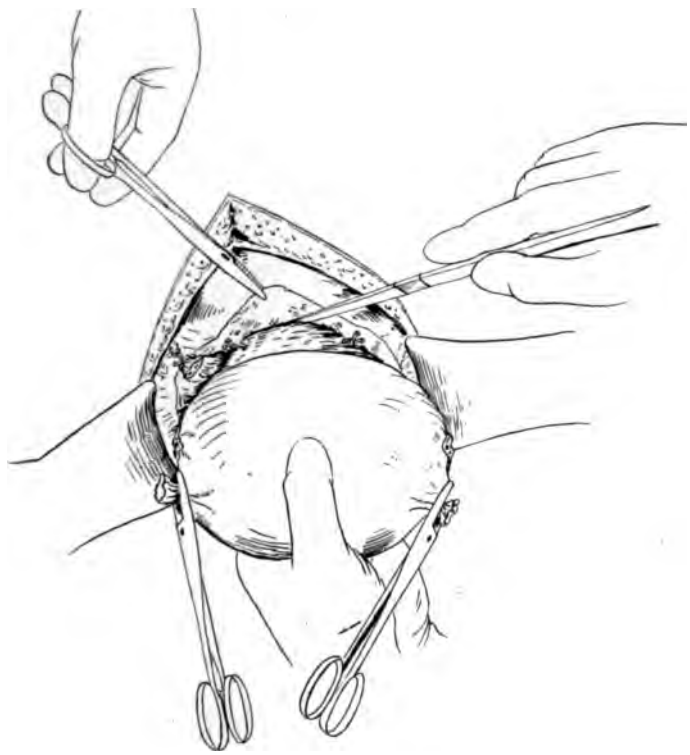


FIG. 211.—Subtotal abdominal hysterectomy. Ligation and separation of the ligaments and vessels complete on both sides. The peritoneal flap and the bladder are being freed from the anterior wall of the cervix.

prolapsus. Where the ligaments are very lax they may be overlapped, or stitched to the opposite sides of the stump, or plicated one upon another.

Closing the Peritoneum.—The next step is to close the peritoneum, representing the anterior and posterior layers of the broad ligament, and to bury the stump of the cervix beneath peritoneal folds. This is accomplished by using a running suture of light catgut beginning at the point of the ligation of the ovarian artery on one side, and carrying it to the center of the cervix. Another suture is employed to close the

opposite side of the broad ligament the two meeting in the center. At this point the free peritoneal edge, representing the reflection from the cervix to the bladder, may be drawn readily over the stump to its posterior serous covering, thus completely burying the cervix.

Complications.—A frequent complication, and one which will cause much trouble to an inexperienced operator, is the extension of the tumor into the folds of the broad ligament, a condition made evident by tension upon the tumor. As tension is made the subperitoneal mass will be drawn well up into the wound, and the peritoneal covering which prevents its complete delivery will be tightly stretched over its

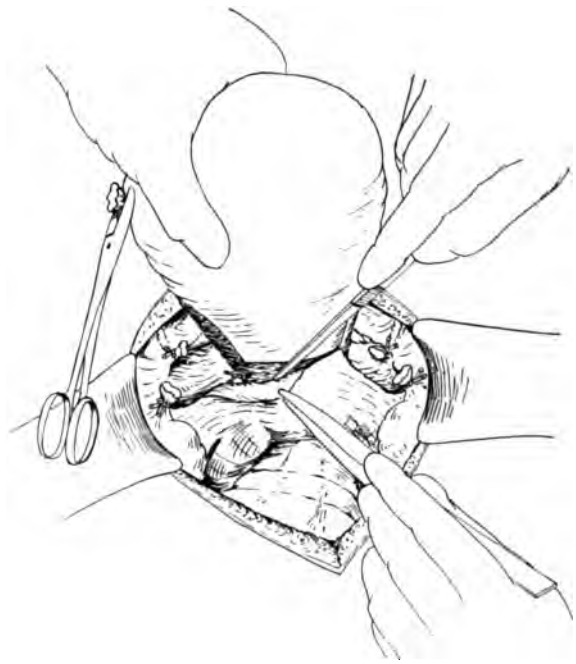


FIG. 212.—Subtotal abdominal hysterectomy. The peritoneal flap is being separated posteriorly from the cervical wall.

surface. At this point the tense peritoneum should be split in a direction parallel with the broad ligament. As this is done further tension upon the tumor will cause it to peel out gradually from its bed, and when it is finally delivered the portion of the broad ligament covering it will collapse into the bottom of the pelvis. Sometimes two or more of these fibroids, which have developed between the folds of the broad ligament and occasionally beneath the peritoneum at other points, will exist to complicate an otherwise ideal operation. No time should be wasted in attempting to deliver them until first the peritoneum beneath which they have grown has been split. As a rule, after such masses have been delivered from their beds the case will become a typical one for the rest of the operative work, as

normal relations with respect to the six points to be ligated will have become reëstablished.

Occasionally tumors will develop beneath the peritoneum and extend so far that an intestine will be stretched more or less tightly over some portion of the growth. These cases should be treated on the same principle as that applied to the tumor developed beneath the peritoneum. By severing the peritoneum at a considerable distance from the intestine, the mass may be enucleated from beneath, leaving the intestine with its bloodvessels and mesentery intact, after which the operation may be proceeded with as in a typical case.

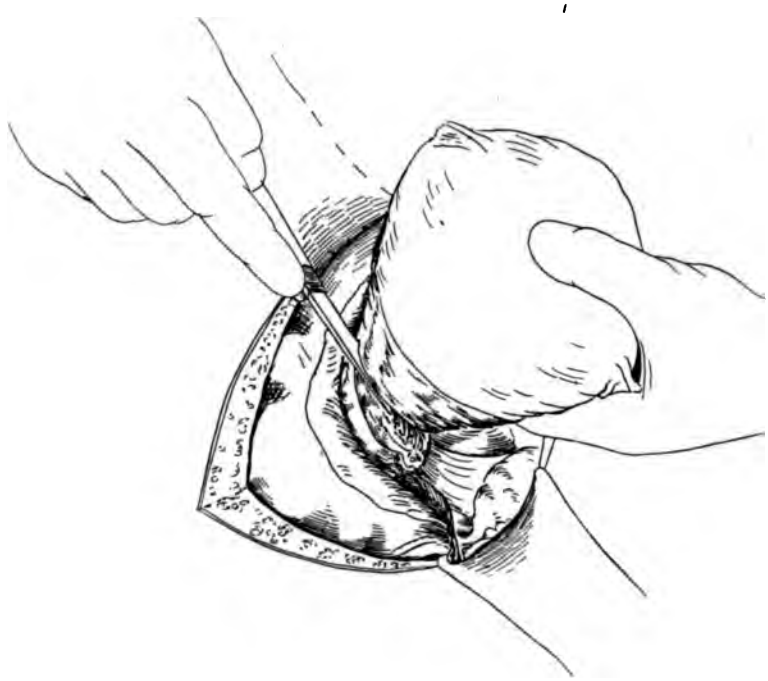


FIG. 213.—Subtotal abdominal hysterectomy. The lower portion of the corpus and upper portion of the cervix having been laid bare, the uterus is amputated on a level with or somewhat below, the internal os.

A complication of unusual difficulty in point of manipulation is that in which a cervical fibroid, developing low on the anterior wall, elevates the bladder well up on the wall of the uterus. Here great care should be taken to enucleate the tumor in such a way as not to interfere with the integrity of the bladder. As the ureters pass from the bladder beneath the broad ligament at either side of the cervix, great caution must be exercised so as not to injure them, and for this reason the enucleation should be carried out with blunt dissection, close upon the tissues of the buried tumor until the neoplasm is gradually isolated. It may then be grasped with a vulsellum and finally delivered in such a way as to allow the bladder to fall back into its normal position.

In enucleating fibroid tumors from beneath the peritoneum, where, one rule should be practised and carefully carried out to *keep close to the tumor*. If subserous tumors are enucleated at points than from the broad ligaments, the slits through which th delivered should be closed carefully with a running catgut sutur

The finished operation of abdominal hysterectomy for fibroids leave the peritoneum of the pelvis completely closed and the representing the stump of the operation, well buried beneath it.

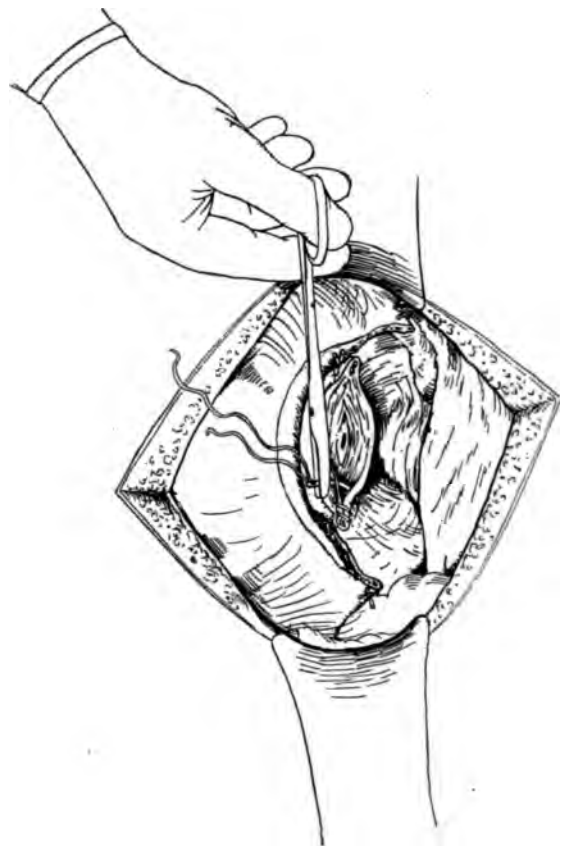


FIG. 213.—Subtotal abdominal hysterectomy. Suturing together the anteri posterior walls of the cervical stump, thus closing the cervical canal.

operation when completed should show the bottom of the smooth, free from bleeding points, and with the peritoneum int all places.

Toilet of the Peritoneum.—The toilet of the peritoneum an closure of the wound are the last steps in this operation. Aft removal of all blood from the bottom of the pelvis the laparotomy should be carefully withdrawn; the intestines are allowed to de and the omentum is spread over their surface beneath the wound

Closure of the Wound.—The wound is then closed in the following manner: The peritoneum is caught up at the upper and lower angles of the wound and in the middle on each side with eight-inch forceps. With these the assistant everts the edges, which are then rapidly whipped together with a continuous catgut suture. If the incision had extended above the umbilicus or if the abdominal recti were diastatic, retention sutures are next placed. These are of silk braid or silk-worm gut and pass through muscle, fascia and skin on each side, from within outward, being so arranged by having a large, curved, cutting-needle on either end. The aponeuroses covering the muscles

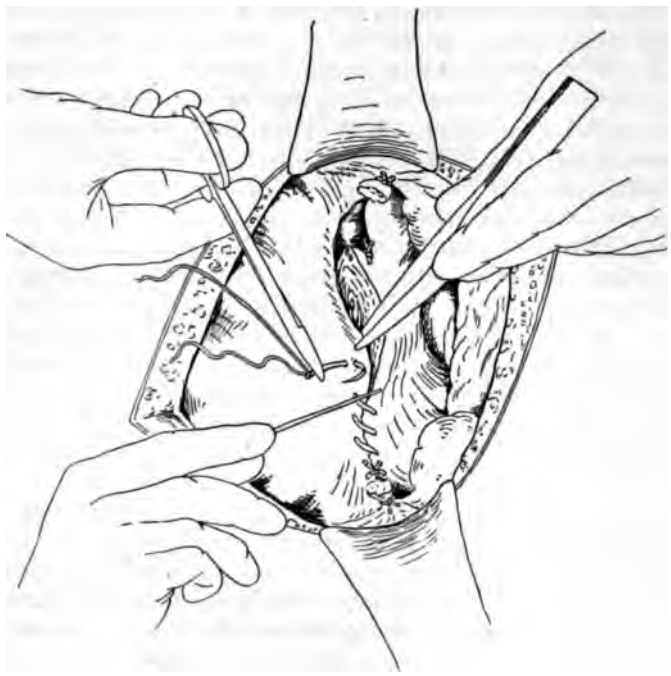


FIG. 215.—Subtotal abdominal hysterectomy. Peritonization. The anterior and posterior peritoneal flaps are brought together from one pelvic wall to the other, thus closing all raw areas and making the stump extraperitoneal.

are closed with strong catgut by interrupted over-and-over sutures, each suture is carefully tied with a surgical knot and two single knots. The skin is next closed by a continuous interlocked silk braid, preferably black. The wound is then touched with tincture of iodine and sealed by a double layer of plain gauze, two inches wide, covering its entire length and secured with collodion. Over this are placed liberal gauze dressings and the whole is firmly bound down with strong strips of adhesive plaster. Over this, in turn, a scultetus binder is fastened.

PANHYSTERECTOMY.—The subtotal or supravaginal extirpation of the uterus just described may not always be sufficient to meet every

pathological condition. At times a fibroid will be situated low down in the cervical wall itself. Again, the vaginal cervix may be diseased on its own account, as in the frequent ectropic or eroded conditions of the multipara; or it may be elongated or hypertrophic. In such cases it seems better to remove the uterus *in toto*, the so-called panhysterectomy. Of recent years certain clinicians have advocated total hysterectomy on the ground that the stump left is a useless organ, subject to disease. Objections to removal of the whole cervix lie in the fact that in so doing the vagina is shortened and the pelvic support to intra-abdominal pressure is weakened. Besides this, subtotal hysterectomy is an easier procedure.

The operation is carried out precisely as in subtotal hysterectomy up to the point where the vesico-uterine fold of the peritoneum is cut through. With the finger or a blunt instrument the bladder and ureters are carefully separated from the cervix, strong traction being exerted on the uterus from above at the same time. As a rule it is best then to place a ligature on either side, particularly since this next pair include the utero-sacral ligaments. As soon as this tissue is severed the remaining structures may be readily stripped down and the cervix freed to its junction with the vaginal vault. The bladder is now separated further along its base until the upper anterior vaginal wall is exposed. This is then grasped with a vulsellum forceps and held up by an assistant. Firm traction being made on the tumor mass from above, the vaginal vault is now opened anteriorly with either scissors or knife and, by a circular incision just escaping the portio, the entire uterus is excised.

Having the vaginal wall in the grasp of the vulsellum, its free edge is now whipped about by an over-and-over running catgut suture. This checks any possible bleeding and puckers the opening until it scarcely admits the finger tip. The round ligaments are now sewn into the edge of this wound on either side, just as before they were attached to the cervical stump. Peritonization is then carried out, the vesical peritoneal flap being stitched to the peritoneum in the pouch of Douglas just behind the posterior vaginal edge.

3. **Combined Vaginal-abdominal Hysterectomy.**—Extirpation of the fibroid uterus by both the vaginal and abdominal routes is rarely indicated. The writer has in mind but one instance where this method was employed. In this case a large tumor occupied the pelvis and rose above the plane of the inlet. At the same time the cervix was so enormously elongated that the portio prolapsed from the vaginal introitus. The vaginal vault was opened as if for vaginal hysterectomy and the cervix excised as in high amputation. The vaginal vault was then left open but tightly packed with gauze in order to check hemorrhage. By the abdominal route the uterus with its multiple fibroids was next extirpated. This required the technic employed in subtotal hysterectomy and the treatment of the pelvic wound that adapted to closure after panhysterectomy. Extirpation of a tumor of such size would have been virtually impossible *per*

vaginam, and removal of the cervix by the abdominal route extremely difficult. The question as to whether, in such cases, the operator should approach his task by the vaginal route first and the abdominal second, or *vice versa*, should be settled by the conditions obtaining in each individual case.

4. **The Treatment of Uterine Myomata in Pregnancy.**—Radium and the *x*-ray being out of the question in pregnancy, the treatment of fibroids lies between other palliative measures and operation. The mere anatomical presence of one or more uterine fibroids is no indication for operation. The health or life of the mother or child is the more important question. All cases, wherever possible, should be allowed to go to term or to viability without regard to the method of delivery that may be best indicated. The danger lies not so much in the length or complications of labor as in the condition of the tumors, whether they be infected or not, or necrotic. At term the question of delivery in the best interests of both mother and child is of first importance, then that of the disposition of the uterus and tumor. The conservative obstetrical method of therapeutic abortion need scarcely be considered today, except in those rare instances when the patient's general condition makes it definitely unwise for her to go through pregnancy. The other obstetrical method, the induction of premature labor after viability, has no advantages over abdominal section. Landau's series of 283 abdominal myomectomies and hysteromyomectomies was attended by a mortality of but 0.7 per cent., results to which the dangers attendant upon the artificial delivery of premature babes *per vias naturales* are not comparable.

The operation should be postponed until rendered a necessity but should be done early enough to anticipate infection, atony of the uterus and exhaustion of the patient. The question as to whether myomectomy or hysterectomy should be performed depends altogether upon conditions found at the time of the laparotomy. Landau advocates two methods: (1) Conservative myomotomy or myomectomy; (2) total extirpation, supravaginal amputation of the uterus, or complete hysterectomy after Cesarean section. The variations in technic depend naturally upon conditions, whether the child is viable or not, the state of the mother, her age and the number of living children, as well as the type of the tumor and the nature of its complications. In the majority of cases Cesarean section after the method of Porro will be the operation of choice. In young women, however, the writer would follow Zweifel in conserving such portions of uterine and ovarian tissue as may serve to maintain the menstrual function.

OPERATIONS DURING PREGNANCY.

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THE puerperal state is so productive of a multitude of signs and symptoms that whenever a surgical problem arises during pregnancy particular care must be taken and the closest observation of an individual case be made before a decision is reached. The very natural antipathy of the patient and the family to resort to surgery at such a time demands that our position be one of absolute surety. One naturally hesitates in advising any operation at this time and if the patient can be carried through to a successful confinement, it is a triumph of surgical judgment. If, on the other hand, a pregnant woman loses her life or that of her child, when they could be saved by operative measures, it is a surgical blunder.

The development of surgery in technic, diagnostic methods and results, has removed from the minds of most obstetricians the fear of major operations during a state of pregnancy, while the surgeon of experience in the presence of a frank and positive indication, resorts to operation considering but little the uterine condition.

Statistics of the large hospitals and the reports of the experience of many surgeons, show that women who come to operation during pregnancy are very few in proportion to the vast number of operations performed daily; yet the problem of operative or non-operative interference is by no means infrequent. So that we venture at this time to present a necessarily short review of what we have considered a most important, though not generally popular aspect of surgery.

In 3248 laparotomies from our records are found 51 patients who were operated upon during the state of pregnancy: Appendicitis, 21; ovarian tumors, 10; encarcerated uterus and chronic inflammatory conditions, 8; fibroid tumors, 5; hydronephrosis, 3. This makes a total of 47 cases. There was an overlapping of appendicitis with ovarian tumors in 2 cases, and with inflammatory conditions in the pelvis in 2 cases.

There were 3 deaths: 1 following a ruptured appendix, 1 a nephrectomy and 1 after an inflammatory case which is listed as cellulitis and, as it was an early case, might have been appendicitis.

Abortion occurred in 8 cases, 6 of which were listed as appendix and inflammatory cases; 1 after nephrectomy and 1 following myomectomy.

We have not included a section upon hernia as the literature is limited and there are not many cases which cannot be held until a more favorable period.

The occurrence of vomiting of the pernicious type is remarked and 8 cases reported in the belief that a certain number may be relieved of this serious symptom by operative measures.

Operations elsewhere than in the abdomen or upon the kidneys present no more danger than in the non-pregnant state.

FIBROIDS.

The literature upon this subject is voluminous. The paper by Lynch includes a bibliography to 1912; since which time 117 titles are found. They are mostly case reports, but the number of articles suggests the general interest in this complication and proves that the occurrence is not uncommon.

From the obstetrical statistics there is a wide variation in frequency as was shown by Lynch after a thorough review of the literature, *i. e.*, from 1 in 125 to 1 in 2000 cases of pregnancy.

From the surgical standpoint, Hofmeier mentions 60 cases of pregnancy found in 1000 fibroid cases; Scipiades 75, in 985 cases; Fabicius 14 pregnancies in 801; Peham mentions 8 pregnancies in 117; Kelly and Cullen in 1674 fibroid operations found 11 cases of pregnancy; while our list is limited to 5 pregnancies in fibroid operations.

It is quite probable that fibroids exist more frequently than suspected as it is no uncommon experience to find such tumors at the time of confinement or by later examination.

The only statistics in American literature analyzing the obstetrical complications which may supervene is a series of 100 cases reported by Lobenstein. The statistics of this group shows: average age twenty-eight and a half years; primipara 43 per cent.; multipara 57 per cent.; presentation before any interference: vertex 65; breech 6; transverse 14; number of abortions: spontaneous 13; after operation 2; hemorrhage at delivery, severe, 14, moderate 86; needing uterine tamponage in 11; adherent placenta 4; gangrenous fibroid in 6; fetal mortality at or near term 6; maternal mortality 4; 15 cases required some obstetrical operation either version or forceps and in 6 cases Cesarean section was necessary. Myomectomy was done in 2 cases, one of which went to term while the other aborted the following day; 85 cases came to full term with spontaneous labor in 75 per cent. which is increased to 87 per cent. if the forceps delivery is included.

Operations during the first four weeks postpartum; 2 complete hysterectomies for sloughing myomas; 1 supravaginal hysterotomy for sloughing myoma; 1 abdominal myomectomy. All other cases were advised to postpone operation until a later date.

The mortality of 4 per cent. included those cases operated upon during the puerperium. The fetal mortality of the 85 cases shows only 6 cases, all were dead on admission.

Pinard's series of 1895 to 1901 shows that some surgical operation was necessary in 4 of his 85 cases and during labor obstetrical operation was done; spontaneous delivery occurred in 54; maternal mortality

was 36 per cent.; 65 children lived; in only 4 cases was a major surgical operation necessary during labor.

As Lynch says, with statistics like these in the literature it seems necessary to require indications for operations during pregnancy.

The demonstration of a pregnant fibroid uterus calls for very careful attention as the possibility of degeneration of the tumor before or after confinement may demand radical surgery. The size, location and chance of obstruction at confinement must be considered. It is an established fact that with the increasing growth of the uterus these tumors may attain extraordinary size and what seems to be a trivial condition in the early months may assume exaggerated proportions at full term. But the fact that a fibroid uterus has conceived is a favorable indication that the tumor will move up into the abdominal cavity along with the uterus.

Their position within the uterine wall has some influence upon the possibility of conception which depends to a great degree upon their proximity to the mucous membrane. Those that encroach or project into the cavity have in our experience caused such hyperplastic changes in the lining, thereby producing the classical symptoms of metrorrhagia, menorrhagia and copious discharge so as to render conception exceptional under these conditions. So that tumors of the subperitoneal or interstitial type furnish a more favorable prognosis to mother and child.

Diagnosis.—The diagnosis is often most difficult. Many surgeons have experienced the dramatic moment, when with the abdomen open, and the uterus exposed, the exact condition is still uncertain; so it is not to be wondered at that the ordinary bimanual examination may oftentimes be unsatisfactory. The cystic feel at the placental site may be thought to be the uterus and that part of the organ still unaffected by the pregnancy may be considered a fibroid. This is essentially the (Braun-von Fernwald) sign of early pregnancy and should be remembered when examining early cases in which this condition is suspected.

Important is the fact that fibroids may be symptomless until pregnancy occurs and that such imposition will lead to the opinion that changes are taking place in the fibroid itself. Thus in the tumor indicating an hysterectomy the possibility of this mistake is suggested by the reports of Carstens, who in 516 cases found that hysterectomy was done before fetal viability in 46.4 per cent. of the cases. It is probable that the greater number of these hysterectomies were performed in the earnest belief that the operation was the proper course of treatment. The opinion is quite freely expressed that expectant treatment is beset with dire danger of abortion, catastrophe at confinement and complication at the puerperium; indeed, the review of the series of Lobenstein and many of the cases reported in the literature reveal such results. But the general appreciation of obstetrical asepsis, the more frequent acceptance by the laity of hospital attention, and the development of better technic in Cesarean section, certainly justifies a conservative course until the viability of the child is assured.

Frequently a first pregnancy occurring late in life will be complicated by the presence of fibroids. In these patients it must be remembered that any measure interrupting fetal development usually means that the prospective mother will never again conceive. This is a consideration which should influence the surgeon to advise against radical surgery at an early date. The mother, even with a full knowledge of the possible complications, is often anxious to assume any risk in behalf of the child. Many cases are reported which were prepared for Cesarean section because the tumor seemed to be in a position to obstruct delivery, and instead of such an operation a spontaneous birth occurred.

Treatment.—Hysterectomy and myomectomy are the operations which most concern the surgeon. There are several well authenticated series which show that maternal and fetal mortality are not prohibitive when indications are positive for their performance.

The following table is copied from Lynch, as it was not possible in our Ramsey County Library to find all the percentages referred to:

	Myomectomy.		Hysterectomy.	
	Mortality. Maternal per cent.	Mortality. Fetal per cent.	Cases.	Maternal Mortalities.
Turner (to 1900), 44 cases	9.0	0	97	13.5
Thinin (1885–1901), 102 cases	7.8	29.4	89	11.1
Le Maire (1892–1901), 93 cases	8.7	26.4	67	7.4
Linterberger (to 1904), 144 cases	7.0	0	91	10.9
Carstens (to 1909), 150 cases	8.6	29.1	204	9.3
Troell (1900–1909), 157 cases	3.9	23.9	133	3.0

The statistics of the more recent years conform to the results of hysterectomy in the non-pregnant state which suggests that in the larger mortality of earlier cases, the element of accident and varied technic may have had some influence.

Myomectomy and hysterectomy are two operations which in the non-pregnant state have become so standardized in methods of procedure as to lead to the expectation of an uninterrupted recovery in every case. The presence of pregnancy during either operation increases the chance of fatal result to the mother but little and in the hands of experienced operators the problems are not greatly increased. Following myomectomy the fetal mortality of 25.9 per cent. (Troell) and 29.1 per cent. (Carstens) is high when compared with 6 per cent. (Lobenstein). The balance is against the performance. It suggests that the operation be only undertaken when the tumor is definitely decided to be obstructive or undergoing degeneration and not simply because a mass has been found in the uterine wall.

There are very successful cases reported and some writers believe that should abortion occur, the uterus has been conserved and is in proper condition for future pregnancies.

In low lying fibroids of the posterior wall there are cases reported in which these were enucleated by vaginal section; in 1 of our cases a large tumor was so removed to be followed by twins the same night.

There is no question but that a great majority of fibroid cases may be let alone and that interference is only exceptionally indicated.

Cesarean section and the Porro operation are rapidly losing their terrors. Carstens reports in his series 40 cases of the former with 5 deaths and 58 of the Porro with 5 deaths over a period leading to 1909. In recent years the technic is more generally known with the result that such operations are attended by ever-increasing success.

The puerperium requires more than ordinary observation as degeneration of the fibroid seems to be more frequent than at other times. Four of our operations were in the three and four months period. In one case 3 subperitoneal tumors were removed; in another 2, in the third case, 1; the fourth, was interstitial; there was one miscarriage, all others going to full term. The fifth case was a cervical myomectomy for a fibroid obstructing delivery.

The conclusions tend toward extreme caution in the differential diagnosis of pregnancy and of fibroid tumor. They prove that myomectomy may be done with small risk to the mother but a high percentage of mortality to the fetus, and that the success of surgical operations at term justify conservative measures during pregnancy.

REFERENCES.

Audebert, J.: De l'ovariotomie pendant la grossesse, Soc. d'obst. de gynec. et de pediat., 1904, vi, 213.

Coulvelaire: Ablation par voie abdominale des tumeursovariennes pelviennes à la fin de la grossesse, Ann. de gynec. et obst., 1912, lx, 277.

Bircher, E.: Ovarialsarkom während der Gravidität, Zentralbl. f. Gynäk., 1907, xxxi, 1378–83.

Duhrssen, A.: Zur Behandlung der die Schwangerschaft und Geburt komplizierenden Tumoren, speziell der cystischen Ovarialtumoren, Deutsch. med. Wchnschr., 1904, xxx, 1529, 1570.

Flatau, S.: Ueber Ovariotomie während der Schwangerschaft, Arch. f. Gynäk., 1907, lxxxii, 452–471.

Flatau, S.: Ovariotomie während der Schwangerschaft, München. med. Wchnschr., 1905, liii, 2542.

Graefe, M.: Zur Ovariotomie in der Schwangerschaft, München. med. Wchnschr., 1906, liii, 675.

Lea, A. W. W.: Ovarian Tumors during Pregnancy and the Puerperium with Notes on Seven Cases, Jour. Obst. and Gynec. British Empire, 1904, vi, 132–140.

Lobenstein, R. W.: Tumors of the Ovary Complicating Pregnancy and Labor, Bull. Lying-In Hosp., New York, 1907, iv, 38–48.

Spencer, H. R.: Ovarian Tumors Complicating Pregnancy, Labor and the Puerperium, Surg., Gynec. and Obst., 1909, viii, 461.

Swan, W. E.: The Management of Solid Tumors of the Ovary Complicating Pregnancy, with Report of Successful Case, Bull. Johns Hopkins Hosp., 1898, ix, 56–61.

von Winckel, F.: Handbuch der Geburtshilfe, 1904, Pt. I, ii, 500–517.

Zickel, G.: Ovarialkarzinom und Gravidität, Zentralbl. f. Gynäk., 1907, xxxi, 385.

APPENDICITIS.

One of the most serious complications of pregnancy is the formation of an intra-abdominal abscess. Those who have had experience in a case of perforative appendicitis under these conditions appreciate the technical difficulties not only in removing the offending organ but in instituting proper lines of drainage. Such operative measures in the presence of an enlarged and sensitive uterus, not only endanger the life of the mother from general peritonitis, but subject her to the possibility of the added shock of abortion or premature labor and the various sequelæ.

Suppurative appendicitis during pregnancy carries with it a mortality which every observer should have in mind when considering the individual case.

In 1906 Meyer reported 143 collective cases. His table shows in both operated and non-operated cases while pregnancy existed, a mortality of 32 per cent., while of 11 cases operated postpartum 36 per cent. mortality resulted.

The frequency with which perforation may take place in cases giving marked symptoms is suggested by the report of Babbler who in 1908 found 103 gangrenous or perforative appendices and 104 non-perforative, in 207 cases where pregnancy was still present.

As late as December, 1914, Murphy in, "Clinic" quotes Findley who mentions 15 cases in which there were 3 deaths. He says that in checking up statistics in other series the mortality in non-operated cases is 77 per cent., which is appalling. In cases operated upon in the first forty-eight hours the mortality is 1.7 per cent.

These tables cover a period when the several problems of appendicitis in general were under discussion and methods of treatment transitory. But a mortality of 32 per cent. is very high and so impressive as to require earnest consideration.

Since 1909 we have found 47 cases reported in which there were 7 deaths, or a mortality of 15 per cent. This is taken without reference to the circumstances of the individual case, and the fact of recovery or death only considered. The mortality in recent years, as compared with that of Meyer, is cut in half. Murphy believes that the cause of this mortality in non-operated cases is due to the fact that the caput coli, omentum and intestines are pushed up which diminishes the opportunity of encapsulating the products of inflammation and permits rupture and the escape of pus into the peritoneal cavity. Imposed on this is the greater chance of hemotogenous infection causing miscarriage and leading toward sepsis of the placental site with possible thrombophlebitis and pyemia. After operation the progress of the disease may be the same but the peritonitis is avoided and the chance of septicemia miminized. Even in the forty-eighth-hour operation, this condition to some degree may obtain. From this reasonable argument, Murphy concludes that operation in these cases is required within the twenty-four-hour period.

Reports of single and small groups of cases are constantly appearing, in which deaths are reported. It is probable that under more definite methods of treatment the mortality rate has improved but the possibility of a fatal result should never be forgotten when concluding that appendicitis of any degree should be cared for in the operating room. However, there is authority for going even so far as to advise removal in borderline conditions as a prophylactic measure.

The discussion of appendicitis complicating pregnancy began soon after the demonstration of this disease as a surgical problem, yet as early as 1848 Hancock, as reported by Cooke, mentions an abdominal abscess containing enteroliths, which was incised four days before delivery of the patient. Most cases were found at autopsy but there

were probably many which, as Mundé states, were diagnosed as pelvic disorders or peritonitis from various causes. If the patient recovered it was because of a perforation into the intestine or by localization and remission of the inflammation.

The frequency of appendicitis is surprisingly small in proportion to the vast number of recorded births. The article of Schmid is the most comprehensive effort upon this subject and includes a complete bibliography up to 1911. With regard to statistics of pregnancy he says: in surgical clinics, appendicitis is frequently treated during the early months of pregnancy and the pregnancy overlooked or not reported, while in the obstetrical clinics the cases come in the later months and the importance of the obstetrical features is allowed to overshadow the appendicular condition. He quotes the following statistics from the different clinics with the years of observation noted:

From Obstetrical Clinics:

	Cases.	Pregnancies.
v. Rosthorn (1906–1909)	13	13,000
Frankel (1873–1898)	5	40,000
v. Rosthorn (1888–1898)	2	270,000
Schauta (1891–1902)	4	34,000
Van Bordt (1905)	4	10,000
Lobenstein	5	30,000

From Surgical Clinics during pregnancy and puerperium.

	Pregnancy. Cases.	Appendectomies.
Sonnenberg	4	2000
Baldwin	3	1800
Vineberg	9	731
Treves	6	1000
Eiselberg	13	3000

These tables seem to have been accepted as sufficient evidence regarding frequency, as we have found no similar subsequent reports.

Such statistics may be taken as authority for the statement that the problem does not often come to the single operator. There are many men doing surgery whose work never appears in print who have a small number of these cases in their records and it is quite probable that if totals were obtainable we would find that the frequency of this complication is greater than shown by present statistics.

The question of operation will in a certain number of cases be settled immediately by the history which reveals attacks previous to conception. Schmid in discussing first attacks and recurrences says that out of 486 cases he obtained definite information on this point in 162. Of these, 125 gave a history of former attacks. It does not therefore appear that pregnancy predisposes to first attacks but it does seem to favor recurrence. There was a time when the opinion was universally expressed in the literature that the state of pregnancy influenced the occurrence of inflammation about the appendix by reason of constipation and the supposed congestion of the pelvic organs. On the contrary the attention of the mother is more carefully turned to her physical condition than at other times and the function of elimination receives constant attention. If a patient gives evidence

of congestion and constipation it is the exception and not th rule. However, with a fairly evident diagnosis coupled with a histor of previous attacks of appendicitis a prompt decision to operate shou not be deferred. Facing such a question the surgeon should reme ber the possibility that pregnancy may excite recurrences and nev lose sight of the great dangers attending abscess formation duri its later months.

Diagnosis of an acute inflammation occurring as a first attack aft conception demands the keenest judgment and closest observation it involves a decision at a time when each of the cardinal sympto of appendicitis may occur from other causes. Of these we need on indicate the complaints which attend the physiological adjustment the patient to her new condition during the earlier months, a during the later months, those that arise from pressure of the grav uterus upon the adjacent organs and the continued stretching of t abdominal walls.

The question of appendicitis is often raised by these women who a influenced by the varied information disseminated among the lai and it is not an uncommon experience to be called upon to pass jud ment upon a train of bizarre symptoms created by fear. Under su circumstances the attitude of the surgeon can be one of assurance a support. For surgeons whose attitude may be very conservati Meyer's report that 42 of 43 cases diagnosed as catarrhal appendici recovered without operation, will be gratifying. There is no reason believe that mild cases should not pursue the favorable course expect in the non-pregnant state. But it should be a law that only in m attacks, where it is possible constantly to observe the condition, th conservative measures are justifiable. If symptoms continue or rec after a few days or a week an operation should be performed.

It is essential that in all cases the cardinal symptoms of fulminati appendicitis be kept constantly in mind as the emergency condition abscess formation is the critical question. We recognize these sym toms as: (1) diffuse abdominal pain; (2) vomiting; (3) the ea localization of pain and tenderness to pressure in the region of t appendix; (4) the occurrence of varying degrees of fever.

It is the sequence of events as emphasized by Murphy which is t determining factor in the non-pregnant state.

Each symptom may be confused in the condition under conside tion. The general pain may be due to beginning abortion or from t excitement of peristalsis, or many other causes. Vomiting is quite t rule, associated as it often is with the nausea of pregnancy. Lo tenderness may be due to the stretching of the abdominal wall wh rigidity may be present or masked by the presence of the enlar uterus. A slight temperature is quite frequent in a normal case wh high temperature suggests many conditions.

The sequence of symptoms as stated has become a law, and wh it is a fact that an appendix may perforate without giving mar symptoms, we have found that a close observation of this rule resulted in a minimum number of diagnostic failures. Its applicat

in pregnancy will aid in the differential diagnosis of pyelitis, extra-uterine pregnancy and inflammatory diseases of the adnexa, all conditions which are possible complications.

Various reasons may lead to delayed operation, resulting in peritonitis or localized abscess. Schmid concludes from the study of his cases that if the peritoneum is involved and interference is not instituted at the proper time the pregnancy is interrupted in the large majority of cases and that this event materially increases the gravity of the prognosis. This fact should have a strong influence upon the operator in selecting the proper steps of operative procedure.

In mild cases where the inflammation is confined to the appendix and the peritonitis involves a small area, the danger of subsequent abortion is small and recovery may be expected as in an ordinary case. The point to be remembered is, that the appendix is often displaced upward and that an incision in the usual location will lead to the vicinity of the right tube, which will pop into the wound, necessitating some manipulation to return it. It is agreed that handling of the pregnant uterus or accessory organs is contra-indicated and this fact argues for an incision high up and farther out to the side than in a non-pregnant case.

If a localized abscess is present and the appendix is buried a serious problem is presented and the judgment of the operator is put to the test, not only as to the institution of proper drainage but as to the advisability of removing the appendix. Without definite data from the experience of others or the statistics of our own cases, but simply based upon a reasonable surgical standpoint, we suggest that the removal of the appendix in the presence of pus depends upon the involvement of the uterus or its appendages in the inflammation. If the inflammation is remote, the appendix may be removed even under difficult circumstances. But if any part of the uterus is involved the operation should cease with the completion of the drainage, thereby producing the minimum amount of traumatism. This conservatism is adopted in the hope that the subsidence of the peritonitis will permit the removal of the appendix at a subsequent date at which time the operation assumes the features of section of chronic adhesions, a procedure which in our experience has no tendency to excite abortion.

When uterine contraction is present, Schmid, Babbler and Findley agree that the proper mode of attack includes (1) abdominal exploration to establish drainage because primary delivery with resulting contraction of the uterus may lead to a rupture of a localized abscess, producing general peritonitis; (2) temporary closure of the abdominal wound and the delivery of the uterine contents by forcible means; (3) the reopening of the abdominal wound and the establishment of drainage, to be followed by the accepted modern methods of post-operative treatment.

When such heroic measures become necessary in a disease which can be cured without mortality through early diagnosis and operation, the responsibility of the surgeon, always profound, is greatly increased. A death during pregnancy, when the joys of expectant motherhood are almost realized, is an event full of tragedy.

REFERENCES.

Alkalaj: Appendicitis i graviditet, Srapki arh. sa celok. lek, 1910, xvi, 9.

Bosse, B., and Fabricius, E.: Ein Fall von metastischer Appendizitis und Cholezystitis im Spätwochenbett, nebst Bemerkungen über septische Infektionen von der Mundhöhle aus, Wien klin. Rundschau., 1910, xxiv, 591, 608.

Brindeau, A.: L'appendicite dans ses rapports avec la puerperalité, Rev. gen. de clin. et de therap., 1910, xxiv, 326-328.

Broniatowski: Appendicitis gangraenosa sub partu, Now. lek., 1911, xxiii, 70–72.

Caturane, M.: Appendicite in Gravidanza con rapporte di tre casi, Arch. ital. di ginec., 1913, xvi, 33-38.

Futh, H.: Ueber dis hohe Mortalität der Appendicitis in graviditate und ihre Ursachen, Med. Klin., 1913, ix, 1575–1577.

Hammer, Wilhelm: Ueber appendicitis im Wochenbett. Berlin g. Grunert, 1913.

Hartmann and Le Grand: Appendicite Meconnue; avortement; mort, Bull. et mém. Soc. anat. de Paris.

Jeannin, C., and Levant: Grossesse de 5 mois et appendicite opérée a chaud; guérison; accouchement au terme normal de la grossesse, Bull. Soc. d'obst. de Paris, 1911, xiv, 473-475.

Jolly, R.: Appendizitis und Schwangerschaft, Frauenarst, 1910, xxv, 530–534.

Kellisch, Lissy: Ueber Appendicitis und Graviditat, Ann. stadt. allg. Krankenh. su München. (1906-1908), 1910, xiv, 217-243.

Lance, M.: Grossesse avec appendicite, Paris chirurg., 1910, ii, 397-399.

Lardennois, G.: Appendicite grossesse, Bull. Soc. d'obst. de Paris, 1911, xiv, 527–530.

Meyer, L.: Appendicitis i Svangerskabet, Ugesk. f. Læger, 1914, lxxvi, 1884–1885.

Paddock, C. E.: Pregnancy Complicated by Appendicitis, Am. Jour. Obst., 1913, lxviii, 401-409.

Peraire: Un cas d'append. avéc œdeme sous-peritoneal et lymphagite compiquee de grossesse, Paris chirurg., 1910, ii, 377-381.

von Rosthorn, A.: Appendicitis und Graviditat, Med. Klin., 1907, p. 339.

Schmid, H. H.: Appendicitis und Gravidität, Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1911, xxiii, 213 332.

Tedenat: Appendicectomie au cours de la grossesse, Bull. Soc. d'obst. et de gynec. de Paris, 1912, i, 996-998.

Vautrin: Les fausses appendicites de la grossesse, Bull. Soc. d'obst. et de gynéc. de Paris, 1914, iii, 351 358.

Wanner: Acute Appendicitis und graviditat, München. med. Wchnschr., 1914, lxi, 1391-1393.

Wohlgemuth, A.: Ueber die Appendicitis beim Weibe, ihre Beziehungen su den Adnexen und zur Tubenschwangerschaft, Berl. klin. Wchnschr., 1912, xlix, 400-403.

THE SURGICAL TREATMENT OF PERNICIOUS VOMITING OF PREGNANCY.

There are three varieties of pernicious vomiting according to the cause or etiology: (1) toxic; (2) neurotic; (3) mechanical.

1. Toxemia is probably the cause of the majority of the cases. It is often taken for granted that such toxemias come from some diseased condition of the liver, kidneys or intestinal canal, because terminal changes are found postmortem in cases dying from pernicious vomiting. It has seemed to us, from the study of the literature, that Dirnoser is correct when he says that this disease is caused by irritation of the sympathetic nervous system due to the absorption of toxins from the interior of the pregnant uterus, either from the fetus or placental tissue.

2. Neurotic or hysterical cases: Winkel thinks that hysteria is frequently the cause of pernicious vomiting. The early months of pregnancy are usually accompanied by sympathetic nervous conditions and vomiting, but excessive vomiting in pregnancy is not common.

3. Mechanical is the class of cases in which we are particularly interested from a surgical standpoint. From our rather limited experience we are led to believe that more than one-half of all severe cases of pernicious vomiting are reflex or mechanical in character.

Symptoms.—Pernicious vomiting when it first appears is like the ordinary morning sickness of pregnancy which passes off during the day. But it rapidly increases in violence until even the sight or smell of food makes the victim retch, and not even liquids can be retained. Loss of flesh and strength is soon apparent. The patients become weaker from day to day, until they pass into coma and die of exhaustion if not relieved by abortion, miscarriage or laparotomy. Pernicious vomiting usually starts about the end of the sixth week of pregnancy, and many cases have died at the end of the second month, but the third month claims the greatest number.

Treatment.—Ochsner's starvation treatment for acute appendicitis is one of the best procedures. This should be combined with rectal feeding; and especially with proctoclysis, introducing as much fluid into the rectum as possible to help elimination, because in these cases, very often, even water cannot be retained when given by mouth. In the meantime the patient should be kept in bed with the foot of the bed elevated from twelve to eighteen inches in order to cause the uterus to occupy a higher position in the pelvis. This part of the treatment should be under the care and direction of an internal medical man or an obstetrician working together with the surgeon. One man alone should never take the responsibility of deciding when surgical interference should take the place of watchful medical care.

If at any time we find that the uterus is fixed in the pelvis, that it cannot be raised as a whole, or if we find that the uterus is retro-displaced, and that it cannot be replaced, then the abdomen should be explored from above. If, however, the uterus is movable and the vomiting continues to a point where the pulse rises to 120, then the uterus should be emptied. The hope in the medical and lay minds in these cases, is, that if they can be carried on to the period of viability the vomiting will disappear. But such a result would only prove that the diagnosis was inaccurate and that the case was not the true pernicious vomiting of pregnancy.

Many operations in cases of true pernicious vomiting have been delayed too long, with the result of the loss of not only the child but the mother as well. We personally know of several such cases; none of which have been put on record.

Our attention was first attracted to this subject by a case seen several years ago with the late Dr. Parks Ritchie of St. Paul. A Mrs. S., aged thirty-three years, had been delivered safely of her first child seven years before; at that time she had suffered only the ordinary or normal amount of vomiting of pregnancy. On account of pelvic distress she was operated upon for ventro-fixation of the uterus; this operation was done in Chicago. Two years later she conceived; at the end of six weeks she commenced to vomit so badly as strongly to suggest pernicious vomiting; she did, however, retain enough food so that she

was able to go on to the fourth month, when she miscarried, then the vomiting immediately stopped. Two years later she again conceived, and vomiting commenced as before. When she started to bleed from the vagina, threatening to miscarry, she was advised to have her uterus loosened up. On opening the abdomen it was found that the anterior wall of the uterus was firmly adherent to the lower abdominal wall over a space of one and one-half inches square. This adhesion was divided with scissors and the raw peritoneal surfaces covered over with catgut sutures. The vomiting ceased on the third day, and she was able to carry her child to full term and be successfully delivered.

We have seen many cases of ventral fixation conceive and carry their children to a successful termination, without pernicious vomiting, but the uterus usually pulled away at least in part from its abdominal attachments; this one was so firmly fixed that it could not pull away. Williams mentions 2 cases of pregnancy following ventro-fixation where Cesarean section was necessary to deliver the child, but they were not associated with pernicious vomiting.

One other case that quickened our interest in this disease, was a young woman, who was seen in her third pregnancy with marked and persistent vomiting. When we found that it was not possible to replace a three months pregnant, retrodisplaced uterus after several trials in the knee-chest position, we advised exploration, and raised the uterus, which was very slightly adherent; her vomiting stopped at once; she did not vomit at all after the effects of the ether had worn off. In a subsequent pregnancy, three years later there was almost no vomiting.

Report of Cases of True Pernicious Vomiting.—Some fifteen years ago we saw in consultation with Drs. Parks Ritchie and Wm. Davis several patients that were only kept alive through the use of rectal alimentation and proctoclysis. When the pulse had risen to 120 or above and the woman was so weak that she could not go on, we emptied the uterus to save life.

One of these cases a few weeks after the uterus had been emptied suffered from a marked attack of appendicitis. This caused us to open the abdomen and then we found, besides a twisted, inflamed and adherent appendix that the posterior surfaces of both broad ligaments were contracted and bound down by strong adhesions.

In a similar case, about the same time Drs. Ritchie and Davis advised abdominal exploration, this was not done, but the uterus was emptied by another surgeon. One month later her appendix was removed. Our knowledge of this case, is, that she had pelvic adhesions as well as appendicitis. She has had no other pregnancies.

Dr. Dredge, of Sandstone, called us to see a case with a clear history of several attacks of appendicitis, constant right-sided abdominal pain and pernicious vomiting. At the operation, March, 1904, we found that she had an adherent appendix with a mass of adhesions running from the appendix down and around the right appendage and to the back of the right broad ligament. The appendix was removed and the adhesions separated; vomiting stopped on the

third day after the operation and she went on to a normal delivery six months later.

Drs. Valentine and Workman, of Tracy, sent among others a young woman twenty-five years of age to consult us. She had been married six months before; she was two months pregnant and had been vomiting everything, even water, for two weeks previous to our seeing her. She had a retrodisplaced fixed uterus. At the operation, January 17, 1905, we removed an adherent appendix, and loosened up the uterus; vomiting stopped on the seventh day and she went on to a normal delivery. I have the histories of 13 such cases all very much alike.

The one, however, which stands out as the most marked and most instructive of them all, was one operated upon about a year ago; this case, Mrs. A. K., was first seen ten years ago with Dr. Cowan of Sandstone. She had at that time been married four months; she was three months pregnant, desperately sick, vomiting all the time, pulse very weak, from 120 to 130. She was not moved from her home, but the uterus was emptied. We saw her again five years later when she was three months pregnant, her second pregnancy, and to save her life the uterus was emptied a second time. When she conceived the third time she came to St. Paul at once and we recognized the fact that her uterus was firmly fixed in the pelvis. When her abdomen was opened it could be plainly seen that the uterus was held down in the pelvis by numerous broad bands of old adhesions that were so strong that some of them had to be divided with scissors. When the adhesions were divided we could see the uterus rise in the pelvis and expand under the eye. The vomiting stopped almost at once and she went on to a normal delivery.

A case reported by Dr. A. E. Strachauer, assistant to Dr. MacLaren, University Hospital, St. Paul, is of great interest in this connection: Operation for pernicious vomiting of pregnancy: Mrs. E. B., aged twenty-four years, was operated upon ten years ago for acutely ruptured appendix. Was in the hospital four months; wound discharged for three months after leaving the hospital. Operated on six years ago for ovarian tumor (?), left-sided. Both operations performed in North Dakota. Patient pregnant two years ago, aborted during second month spontaneously, moderate nausea and vomited at times. Present illness: Began with present pregnancy five months ago; last month vomiting greatly increased so that the patient is now in an extreme and serious condition. Patient complained of much pain in right lower quadrant. Operation at St. Mary's hospital, Minneapolis, suprapubic incision, area of adhesion divided with scissors and uterine area sutured for purposes of hemostasis; adhesions in pelvis about the uterus freed with hand. Two definite bands one small and the second the size of a lead pencil from the uterus off into the abdominal cavity, divided. Vomiting ceased the second day after the operation; pain greatly decreased at the time of leaving the hospital. A stitch abscess developed after the patient returned home, and discharged for several weeks, perhaps due to a hard chromic catgut knot. The vomiting at no time recurred during her pregnancy.

H. Delageniere, in *Gaz. de Gynec.*, 1914, reports 5 cases of pernicious

vomiting of pregnancy associated with appendicitis, which he had operated upon for chronic appendicitis, curing the pernicious vomiting without interfering with the pregnancy. He believes that a majority of the cases are due to irritation of the peritoneum.

Our experience would lead us to believe that although pelvic adhesions were often due to the appendix, the adhesions limiting the expansion of the growing, pregnant uterus were of much greater importance than the appendix itself. We also feel that it is unsafe to take the position, that the slight changes in the appendiceal wall, which are so often called chronic appendicitis are sufficient to explain the pernicious vomiting of a pregnant woman, but that we should go on, even after finding an adherent appendix and determine whether or not there are uterine adhesions or even contraction of the posterior surface of the broad ligaments, for such adhesions are of the greatest importance because they prevent the normal expansion of the pregnant uterus.

In our list of 19 cases of pernicious vomiting are 2 deaths. In both of the fatal cases the uterus was emptied. One was a case which we had never previously seen, but which had been under the care of men of great judgment and ability. Nos. II and III of our list are cases operated upon twelve or thirteen years ago, before we came to appreciate the importance of pelvic adhesions. One woman, thirteen years ago, when her uterus was emptied, developed, even under the most careful and strict antisepsis, a double tuboövarian abscess, which was opened and drained through the vagina, with recovery. In spite of her double tubal suppuration, she soon conceived again and had to have her uterus cleaned out a second time to save her life; her abdomen was never explored.

We, then, have 14 cases for consideration; 1 death; 10 children survived; although 1 has not come to full term; 9 children have been safely delivered in cases that in earlier years we were accustomed to destroy, and one more has almost reached full term.

Cases in which the Abdomen was not Opened.

CASE I.—Drs. E. Spencer and William Davis. Pernicious vomiting; rectal proctoclysis for four weeks; uterus emptied; died.

CASE II.—Drs. MacLaren and Ritchie. Three children; with former pregnancies had moderate vomiting; time, two and a half months; pernicious vomiting for three weeks; pulse, 120; uterus emptied; recovery.

CASE III.—Drs. MacLaren and Ritchie. Fifth pregnancy; time, two and a half months; pernicious vomiting for three weeks; pulse, 130; uterus emptied; recovery.

CASE IV.—Drs. MacLaren and Ritchie. Pernicious vomiting for three weeks; saline proctoclysis; recovery.

CASE V.—Dr. Parks Ritchie. Three children; time, two and a half months; uterus cleaned out for pernicious vomiting; opened abdomen one month later; adherent appendix and uterine adhesions; recovery.

Cases in which the Abdomen was Opened.

CASE VI.—Drs. MacLaren and Ritchie. One child; time, two and a half months; delivery normal; pernicious vomiting; encarcerated uterus; ventro-fixation two years before.

CASE VII.—MacLaren and Ritchie. Two children; time, three months; normal delivery; encarcerated uterus; retrodisplacement; recovery.

CASE VIII.—Drs. MacLaren and Ritchie. One child; time, two and a half months; uterus cleaned out two months before for pernicious vomiting; appendix with adhesions; recovery.

CASE IX.—Drs. MacLaren and Ritchie. Primipara; two months; normal delivery; adhesions to appendix; adhesions to back of right broad ligament; recovery.

CASE X.—Drs. MacLaren and Ritchie. Two children; three months; normal delivery; encarcerated adhesions; retrodisplaced uterus; recovery.

CASE XI.—Drs. MacLaren and Ritchie. Primipara; two months; encarcerated adhesions; retrodisplaced uterus; recovery.

C SE XII.—Drs. MacLaren and Ritchie. One child; normal delivery; two and a half months; encarcerated adhesions; retrodisplaced uterus; recovery.

CASE XIII.—Drs. MacLaren and Ritchie. Two children; delivery; three months; pelvic cellulitis; exploration five days later; uterus empty; patient died nine days after continued vomiting; died on the fourteenth day.

CASE XIV.—Drs. MacLaren and Ritchie. Three children; normal; chronic adhesions to appendix; recovery.

CASE XV.—Drs. MacLaren and Ritchie. Primipara; two months; ovarian cyst; vomited; wound opened and vomiting stopped; normal recovery.

CASE XVI.—Drs. MacLaren and Ritchie. Primipara; six weeks; normal; uterus emptied twice before for pernicious vomiting; uterus fixed in pelvis; adhesions behind the uterus and both broad ligaments; recovery.

CASE XVII.—Drs. MacLaren and Ritchie. Primipara; two months; uterus fixed; pelvic adhesions behind the uterus and both broad ligaments; miscarriage two months later; recovery.

CASE XVIII.—Drs. MacLaren and Ritchie. One child; two months; uterus not cleaned out; sister died from pernicious vomiting after the uterus was emptied; chronic adhesions to appendix; uterus emptied two weeks after operation; recovery.

CASE XIX.—Dr. A. C. Strahauer. Pelvic adhesions attached to the uterus; not delivered.

REFERENCES.

Audebert, J.: Cholecystite gravidique, Jour. de méd. de Paris, 1914, xxvi, 492-494.

Audebert, J., and Gilles, R.: Rapports de la lithiase biliaire avéc la grossesse et l'accouchement, Ann. de gynéc. et d'obst., 1910, vii, 788-811.

Bettman, H. W.: Cholecystitis: with Suggestions for the Prevention of Gall-stones, Med. Record, 1908, lxxiv, 923-925.

Branson, Laura: Cholecystitis and Cholelithiasis in Their Relation to Pregnancy, Jour. Am. Med. Assn., 1911, lvii, 1690–1694.

Brothers, A.: Report of a Case from Which 205 Gall-stones were Removed Simultaneously with Operation on Cervix Uteri and Uterine Adnexa, Am. Jour. Surg., 1909, xxiii, 142.

Burke, R. A.: Association of Cholelithiasis and Pregnancy, Jour. Michigan Med. Soc., 1914, xiii, 599.

Graham, Joseph: Gall-stones Complicating Pregnancy and the Puerperium, Southern Med. Jour., 1914, vii, 389–392.

Green, R. M.: Cholecystitis and Cholelithiasis Associated with Pregnancy, Boston Med. and Surg. Jour., 1913, clxviii, 679–681.

Grube, K.: Ueber die Bedeutung der Schwangerschaft für die Entstehung der Gallensteinkrankheit, Veröffentl. d. balneol. Gesellsch., 1912, xxiii, 13–16.

Hoffbauer, J.: Ueber Relationen weiblicher Generatiensvorgänge zur Klinik der Cholelithiasis, Med. Klin., 1909, v, 239–241.

M'Nee, J. W.: Recent Work on the Etiology of Gall-stones, Glasgow Med. Jour., 1914, lxxxi, 106–115.

Peterson, R.: Gall-stones During Pregnancy and the Puerperium, Surg., Gynec. and Obst., 1910, xi, 1–11.

Ploger, Ruth: Die Gallensteinkrankheit in ihrer Beziehung zur Schwangerschaft und zum Wochenbett, Beitr. z. klin. Chir., 1910, lxix, 275–295.

Titus: Statistical Study of a Series of 274 Abortions Occurring in the Obstetrical Department of the Johns Hopkins Hospital, Am. Jour. Obst., 1912, lxv, 960–980.

Watson, J.: Three Cases of Gall-stones Associated with Pregnancy, Guy's Hospital Gaz., 1914, xxviii, 225.

CHOLECYSTITIS.

In 2109 operations upon the gall-bladder in our private work we have had 2 cases which came with a history indicating that a cystic gall-bladder had formed during the pains of recent childbirth. In three years service at the University Hospital, 1 case was operated upon for gall-stones during the fifth month of pregnancy. Cholecystitis as a complication of pregnancy therefore has not impressed us as of great importance or that it involves questions other than those which arise in the non-pregnant state.

Discussion of this situation is very meager in both current literature and text-books. In the year 1910 two articles appeared which cover the ground so thoroughly as to influence us very much in writing this section. Peterson and Plögar almost at the same date present papers and review the subject, reaching conclusions which are essentially similar. The former found 25 references of which 7 were in American journals to which are added 10 others taken from various books and from chapters dealing mainly with the general subject.

Peterson's bibliography shows that in this country Illoway, 1889, reported a case of icterus gravidarum. In 1890, Rhett writes of a cholecystotomy on a pregnant woman. In 1893, Boorse mentions a case of pregnancy complicated by the expression of biliary calculi.

In 1893, Willien reports a cholecystotomy in the third month of pregnancy. In 1895 Vineberg reports 2 cases of cholecystitis in the puerperium and says that he was able to find but 4 cases previous to his article.

In 1895, A. B. Davis reports a case of cholecystectomy in the seventh month without interrupting pregnancy.

Plöger in 1910 gives a record of 42 cases, of these 22 had gall-stone colic in the puerperium and in 19 of these it was the first attack. The

remaining 20 attributed the beginning or increase in the severity of their gall-stone pains to some pregnancy.

Peterson collected 25 cases complicating pregnancy including his own case and 10 complicating the puerperium. These are cases proved by operation or through finding of calculi in the stool. Otherwise he could have included 20 cases of Huchard and 51 of Berline-Herwig.

Since 1910 Green reports 2 cases following miscarriage; Branson 4 cases; Audebert 1 case; Graham 6 cases, a rather meager list when the frequency of gall-stone operation is considered.

While the surgical problem of diagnosis and operative relief may not involve any special problems, the question of the causal association of cholecystitis and cholelithiasis with pregnancy is very interesting.

This relationship is suggested by the relative frequency of gall-stones in para women to the occurrence in men on the one hand and virgins or sterile women on the other. Ochsner reported 50 cases in which there were four times as many females as males. Kehr reports a series of 720 laparotomies upon 655 patients of which 536 were women and 119 men. Mayo makes the statement that gall-stones occur three times in women to one in men. The division of our cases show: 183 women and 26 men, *i. e.*, seven times as frequent.

Schroeder says that 90 per cent. of women operated upon have borne children. Peterson in a series of his work finds that 75 per cent. of 64 cases had had children.

Grube giving a table of 657 cases of gall-stone proves that 613 cases had had children while 44 were without—73.4 per cent. In our list there were 183 married and 33 unmarried or sterile women.

Arthur's collection tends to the same conclusions and to such a degree that from a clinical standpoint there is sufficient evidence positively to state that pregnancy produces changes in the biliary system which favor the invasion of microörganisms.

Grube concisely states that these changes are:

1. Stasis of the bile.
2. Increase of cholesterin in the bile.
3. Protein decomposition.
4. Cell desquamation.
5. Hyperemia of the mucosa of the bile ducts.

He agrees with Hofbauer that cholelithiasis is due to the above processes plus bacterial infection and says that as a result of investigations of the livers of women who have died during or just before or after labor, that all of the above-named conditions are chacteristic of pregnancy.

M'Nee says that on a basis of investigation carried on by himself and Ashoff, that some forms of stones originate in the aseptic and uninflamed bladder. M'Nee believes there is a definite relationship between gall-stones and pregnancy taking into consideration that the most common age of onset corresponds to the period of childbearing and the number of cases of gall-stones in women who have borne children.

He believes that the pressure of the uterus causes stasis. He also found that the cholesterine contents of bile were greatly increased in 5 women who died during, just before or after labor. These findings coincide with those of Grube.

Peterson says that in pregnancy it is significant that in nearly one-third of the cases the period of onset is at that time of gestation when the uterus is approaching the level of the umbilicus, sending the intestines upward and when the growing fetus is beginning to hamper the eliminative powers of the liver. In the puerperium in one-half of the cases, the attacks occurred during the first seven days postpartum suggesting traumatism of the biliary passages during labor. He quotes Vineberg who says the great eliminative processes going on at this period, the change in the intra-abdominal pressure and the forced rest in bed with the attendant constipation, all favor these attacks.

The occurrence of jaundice is most important as the presence of icterus materially affects the uterine contents and the nearer to term the greater the possibility of exciting labor. Peterson found that in 15 cases of his series of 25, jaundice was present. He seems to prove by a study of the cases with reference to the location of the gall-stones and jaundice that pregnancy can produce jaundice in a constitutional way without the aid of obstruction in shape of calculi.

The diagnosis should not be difficult when the attacks are typical. Chills and fever usually mean obstruction to the common duct, with which jaundice in some degree is early associated. Early and frequent urinalysis is most important with the purpose of excluding pyelitis. The demonstration of traces of bile in the case of obscure diagnosis will permit of an early decision.

In the postpartum state chills and fever suggest puerperal sepsis and it is in this situation that the greatest difficulty of diagnosis occurs. Reliance therefore must be placed upon symptoms local to the gall-bladder and a history of previous attacks.

The operative mortality is 13.04 per cent. for 23 cases. This is influenced as in any case by the complications of common duct involvement and the degree and extent of inflammatory processes. The condition of pregnancy seems to have but little effect. The deaths reported were from rupture of the gall-bladder, cases of empyema or extensive or prolonged operative procedures required by the conditions found. The occurrence of miscarriage is dependent upon the pathology present more than upon the effect of the operation. In Peterson's cases, two started before operation and three after. All of the latter were cases of extreme infection with chills, fever and jaundice.

Graham reports a case in the sixth month in which the gall-bladder was ruptured by a blow on the abdomen. At operation three gall-stones were found in the abdomen, one in the gall-bladder, and two in the cystic duct. He gives detailed histories of four others which were operated upon during pregnancy, all of whom went to term. One other case refused operation and died two years later from complete obstruction of the common duct.

Linz in discussing Graham's paper describes a case which ruptured during labor. The patient died of general peritonitis and at the post-mortem 250 gall-stones were found scattered through the abdominal cavity.

These are, however, the exceptional cases and must be classed as accidents rather than as the results of pregnancy.

There is evidence to believe that operation on the gall-bladder in which complications are not marked has but little effect in producing abortion and that recovery may be expected as in the ordinary case. This fact justifies us in advising removal at any time when the symptoms become frank and at any time during the pregnant state, especially when a history of frequent and recurrent attacks is obtained. The tendency of cholecystitis to subside for long periods is to be remembered so that in mild and short attacks operation may be postponed until after delivery with a minimum amount of risk.

This leads to the very general advice that operative procedures can be undertaken upon indications which would influence the surgeon in any case of cholecystitis but with the added note of conservatism.

PYELITIS AND PYELONEPHRITIS.

Symptoms of bacterial infection of the kidney become manifest more frequently during the later months of pregnancy. This statement is borne out by most of the reported cases in the literature, of which Albeck's series of 52 is selected as an example: 18 in the tenth month; 19 in the ninth month; 8 in the eighth; 9 in the seventh; 4 in the sixth; 2 in the fifth.

The frequency of occurrence is shown by the report of the Copenhagen Maternity, which gives these figures: 450 cases in 7648 pregnancies, or 5.86 per cent. This percentage of nearly 6 in 100 cases seems at first sight to be high and is probably the result of close institutional observation, as not many obstetricians in general practice can admit an equivalent experience. Such statistics suggest, that many times pyelitis may be overlooked or the symptoms be transitory and ascribed to other causes.

The infecting agent is some form of the colon bacillus, although occasionally some other pathological bacterium may be present. Andrews reports 19 cases, 13 of which were examined bacteriologically finding B. coli communis in 7; B. coli formis in 5; Streptococcus albus and diphtheria bacillus in 1.

In considering the avenues by which the causative agent gains access to the field of activity, the preponderance of evidence is in favor of an ascending infection. There are some few cases reported which from their particular symptoms and surgical findings suggest the hematogenous form. Most writers favor the ureteral tube as the channel by which the bacilli gain access to the kidney pelvis. The occurrence of the inflammation during the later months is taken as evidence that the growing uterus produces some pressure upon or influences the form

treatment, and most writers reporting their cases state that it is the exceptional case in which an early attack upon the kidney is necessary.

It seems to be agreed that there will be a time at which the cystoscope may be used to demonstrate the character and the location of the inflammation. Most communities in this country have some one with experience, and such an examination should be made in order that cases of pyonephrosis may be excluded, and the relative competency of the renal organs proved. Local anesthesia and some of the simpler methods of direct cystoscopy can be employed with a minimum amount of risk. Barth, however, reports a case which aborted following ureteral catheterization. Williamson and Barrie report a death occurring twelve hours following the examination under general anesthesia; so that the procedure is not entirely free from danger.

Cystoscopy and catheterization is not confined to the field of diagnosis but in the opinion of many, presents a most efficient therapeutic measure. Glendining says that catheterization of the ureters is a ready method of diagnosis, relieves pain, reduces temperature, drains the kidney pelvis and thus aids in recovery. If lavage is indicated he uses a saline solution.

Venus maintains that all severe cases should be so treated and that often great benefit results.

Davis employs lavage with weak antiseptic solutions but unless relief is obtained in due time, resorts to surgical measures.

McDonald believes ureteral catheterization is beneficial but that lavage in the later stages can be of little use.

These quotations are given as examples of the general trend of advice for the use of this method and that by these means improvement to such an extent is obtained as to permit a continuation of the pregnancy. This operation in combination with dietetic and medicinal measures, with the taking of distilled water in considerable quantities at short intervals, represents the conservative treatment which in the majority of cases yields the desired results.

Keeping always in mind the possibility of pressure by the uterus, postural treatment has proved efficient. The patient should be directed to lie upon the side opposite to the one affected and even to assume the knee-chest position at intervals, in the hope that the stagnation of the urine may be prevented or overcome. The free use of urinary antiseptics, with hexamethylenamine as a constituent and of fluids in quantity is indicated. Attention is called to the treatment of cystitis with small irrigations of silver nitrate in solution of 1 to 3000.

Yet conscientious treatment along these lines may not yield satisfactory progress and it may be necessary to resort to nephrotomy, the induction of premature labor or abortion.

Renal surgery finds its application when the disease is demonstrated to be unilateral, and the symptoms of hydronephrosis, pyonephrosis, or perinephritic abscess are positive.

Nephrotomy with drainage is the operation of choice and nephrectomy is indicated only when the destructive processes are so advanced as to make manifest the absolute incompetency of the organ.

The induction of premature labor, if the pregnancy is far advanced, as suggested by Legueu, may be the best course. Opitz, in 65 cases having their first attack, performed this operation 10 times; in 8 the fever immediately fell to normal while in 2 it continued for a longer course. If the child is not near term and there is evidence of extensive involvement of one kidney, nephrotomy may be necessary.

We have maintained a conservative attitude regarding renal surgery because of our earlier experience in which a death resulted from nephrectomy. When the kidney was opened an infected hydronephrosis was found. The patient miscarried the following day and died forty-eight hours after operation. In another case in which we were consulted, the kidney was drained, with miscarriage soon following. This patient, however, recovered to go through subsequent confinements during which she developed nephritic symptoms but they were controlled without operation, permitting successful deliveries.

We have seen cases in which fever of varying degrees was present for months yet confinement occurred without complications and the mothers recovered their health with a clearing up of the urine. One case had a mild return of the pyelitis during the second confinement, while another becoming pregnant eight years later presented no symptoms whatever.

It is again stated that it is the very exceptional case for which radical measures are required. It is reasonable to believe that some women will develop a renal affection, independent of the pregnancy, which will be distinctly surgical, but with pyelitis it is suggestive when we say that we have not found a case reported as dying from this condition. Pyelitis may carry with it protracted illness but mortality is wanting. With the assurance that the symptoms will disappear after delivery and that recovery will be complete in the vast majority of instances, the treatment should be a watchful and painstaking care of the mother along medical lines.

REFERENCES.

Adamson, R. O.: Glasgow Obst. and Gynec. Soc., 1906, v, 190-194.
Albrecht: Zentralbl. f. Gynäk., 1913, xxxvi, 315.
Andrews, H. R.: British Med. Jour., 1912, i, 1112–1114.
Barth: Deutsch. Ztschr. f. Chir., 1906, lxxxv, 57.
Bauereisen, A.: Jahresk. f. ärztl. Fortbild., 1914, v, 27.
Bazy: Bull. et mém. Soc. de Chir. de Paris, 1910, xxxvi, 826.
Bonnaire and Levant: Bull. Soc. d'obst. de Paris, 1911, xiv, 428.
Brongerama, H.: Nederl. Tijdschr. v. Geneesk, 1913, i, 529–535.
Burnett, Napier: Jour. Obst. and Gynec. British Empire, 1910, xviii, 43-51, 81-94.
Burton, A. W.: South African Med. Rec., 1914, xii, 403–405.
Cathala: l'Obstetrique, x, 165–166.
Chace, A. E.: Jour. Am. Med. Assn., 1911, lvi, 38.
Chauffard: Rev. gen. de clin. et de thérap., 1913, xxvii, 533–535.
Cochrane, F. L.: Internat. Jour. Surg., 1910, xxiii, 194–196.
Crew, F. D.: British Med. Jour., 1912, i, 828.

Cova: Ann. di ostet. e ginec., 1903, xxv, 692–705.
Cumston, C. G.: Boston Med. and Surg. Jour., 1910, 163–945.
Davis, E. P.: Jour. Am. Med. Assn., 1912, lix, 859.
Davis, E. P.: Surg., Gynec. and Obst., 1914, xviii, 116–119.
Doederlein, T. J.: Jour. Am. Med. Assn., 1911, lvi, 199.
Evans, David J.: Montreal Med. Jour., 1909, xxxviii, 71–75.
Fleischhauer, H.: Ztschr. f. Gynäk.Urol., 1911–1912, iii, 221–232.
Franz, K.: Med. Klin., 1915, xl, 7–179.
Franz, R.: Med. Klin., 1915, xi, 190.
Giusti, G.: Ann. di ostet. e. ginec., 1914, ii, 113–157.
Glendining, B.: Arch. Middlesex Hosp., 1911, xxiv, 21–26.
Gueniot, M. Paul: Bull. de la Soc. d'obst. de Paris, 1905, viii, 202–205.
Hourtoule, V.: Jour. d'urol. méd. et chir., 1914, vi, 55–59.
Hunner, Gutyl: Surg., Gynec. and Obst., 1912, xv, 444.
Jaeger, F.: Ztschr. f. Gynäk. Urol., 1911–1912, iii, 233–236.
Johnnsson, S.: Ztschr. f. Gynäk. Urol., 1911–1912, iii, 279–288.
Kehrer, E.: Ztschr. f. Gynäk. Urol., 1911, iii, 24–40.
Kermauner, F.: Ztschr. f. Gynäk. Urol., 1911, ii, 291–294.
LeFur, L.: Paris Chir., 1913, v, 105–120.
Legueu: Rev. de gynéc. et de la chir. abd., 1904, viii, 431–446.
Legueu: Soc. d'obst., gynéc. et de ped., 1907, ix, 259–263.
Louria, L.: New York Med. Jour., 1911, xciii, 1073–1138.
McDonald, E.: Am. Med., 1910, v, 621–632.
Macfarlane, W. D.: Tr. Glasgow Obst. and Gynec. Soc., 1913, ix, 87–90.
Macfarlane, C.: Woman's Med. Jour., 1911, xxi, 189.
Mansfeld: Verhandl. d. deutsch; Gesellsch. f. Gynäk., 1911, xiv, 810.
Markus, N.: Berl. klin. Wchnschr., 1911, xlviii, 757.
Opitz, E.: Ztschr. f. Geburtsh. u. Gynäk., 1905, lv, 209.
Pasteau, O.: Paris Chir., 1913, v, 645–655.
Pilcher, P. M.: Surg., Gynec. and Obst., 1911, i, 127–142.
Pinard: Rev. gén. de clin. et de therap., 1911, xxv, 134.
Reed, C. B.: Surg., Gynec. and Obst., 1907, iv, 196–198.
Rosinsky: München. med. Wchnschr., 1910, lvii, 2110.
Routh, C. F.: British Med. Jour., 1910, i, 191.
Sauvage: Soc. d'obst. de gynéc. et de pediat. de Paris, 1910, xii, 122–128.
Sippel, A.: Zentralbl. f. Gynäk., 1905, xxix, 1121.
Smith, Carroll: Am. Jour. Dermat. and Gen. Urin. Dis., 1910, xiv, 532–534.
Stoeckel: München. med. Wchnschr., 1913, lx, 2147.
Stoeckel, W.: Ztschr. f. Gynäk. Urol., 1908, i, 43.
Tuffier, T.: Bull. et mém. Soc. de chir. de Paris, 1910, xxxvi, 783–787.
Tuley, H. E.: Kentucky Med. Jour., 1910, viii, 1806.
Venus, E.: Wien. klin. Rundshau, 1911, xxv, 517–536.
Vineberg, H. N.: Am. Jour. Obst., 1908, lvii, 769–789.
Violet: Lyon méd., 1914, cxxii, 1271–1273.
Voorhees, J. D.: Am. Jour. Obst., 1910, lxi, 501–505.
Wallich, V.: Soc. d'obst. de gynéc. et de pediat. de Paris, 1910, xii, 117–121.
Ward, E.: Quarterly Jour. Med., 1908, ii, 69–84.
Weidler, F.: Gynäk. Rundschau, 1908, ii, 772–776.
Weymeersch, A.: Scalpel. et liege méd., 1913, lxvi, 775–777.
Widal, F., and Benard, R.: Jour. d'urol. méd. et chir., 1912, i, 317–322.
Williamson, H., and Barris, J.: Jour. Obst. and Gynec. British Empire, xx, 244–248–266.

OVARIAN TUMORS.

The subject of ovarian tumors complicating pregnancy has been frequently reviewed in the current literature. Most writers refer to McKerron's article in 1913 which includes references to that date. Danforth supplements the bibliography to 1914, since which time but few papers have appeared; the most important of which are by Danforth and Schauta.

Our experience is limited to 10 cases operated upon during pregnancy and 1 case in which a large multilocular ovarian tumor, equal in size to a

pregnant uterus was removed in the second week following confinement. The earliest operation was done in the sixth week of pregnancy and the latest in the fifth month; all the mothers recovered and went to full term.

This small list of cases shows that the risk of operation during the early months is very small.

It is not to be concluded that such conditions are without danger and while recent reports are most favorable there is evidence in the literature that abortion occurs and that changes in the tumor itself may lead to serious results in the mother.

From the obstetrical aspect the frequency of ovarian tumors is not great. In 1904 von Winkel quotes Fehling who found in 17,832 deliveries 20 cases of tumor, that is, one in 891. Löhlein reports 2 cases in 13,000. McKerron estimates one case to 15,000, and Lobenstein finds 9 cases in 42,000 pregnancies.

It is interesting to note that Swan searching the literature from 1861 to 1898 was able to find but 14 cases reported in which the tumor was solid, 6.8 per cent. McKerron found 19 solid tumors in a series of 862 cases in which the character of the tumor was especially stated. Jetter in 166 cases reports 6.6 per cent. solid tumors. Solid tumors are but a small proportion of ovarians so that in operating the expectation is that some form of a cyst will be found. Dermoids, however, appear more frequently, amounting to 25 per cent. of the cases according to McKerron, who ascribes this observation to the fact that dermoids are symptomless until pregnancy occurs and produces pressure.

The accidents possible to any case occur more often in the presence of a pregnant uterus. Danforth says that torsion of the tumor happens three times as often in pregnancy as in those found apart. McKerron found 60 cases of torsion and believes that it happens in about 1 out of 8 cases.

Torsion of the uterus may occur and abortion result from interference with the circulation of the organ. McKerron found 8 cases and quotes Schultz who first called attention to this possibility as having seen several cases in which twisting was as great as 180 degrees.

The most serious complication is rupture. Danforth says this may occur in one out of four times and at any period of the pregnancy. The presence of suppuration of course materially adds to the gravity of the situation.

Very large tumors may cause abortion but when definitely cystic and the size dependent mainly on the quantity of fluid, they have little influence beyond producing enormous distention.

The diagnosis is many times difficult although often an ovarian tumor is readily determined, especially those above the pelvic brim. The globular form, varying degrees of fluctuation, mobility and location to one side of the uterus or the other is characteristic. When choked in the pelvis it is possible to confuse the condition with a retroverted uterus. Under such circumstances a finger in the rectum is suggested as permitting a deeper examination of the contents of the pelvis than

is possible otherwise. By such means the contour, elasticity and fixation of the mass is more evident. The differentiation from a fibroid is many times not possible and so a conclusion often is reached that the tumor is a soft fibroid or a hard ovarian. A correct decision is most important as the present opinion as to treatment of these two forms of tumors, is, that ovarians call for radical surgery while with fibroid uteri which have conceived great conservation is indicated. Frequent examination with particular attention to the condition of the bowels and bladder may reveal the exact diagnosis.

The prognosis is very favorable to both mother and child if the operation is undertaken in the early months of pregnancy. Even in large series taken without reference to time of operation or conditions under which it is performed the mortality is not large. F. Winckel quotes Dsirne 5.9 per cent., Wahmer 5.45 per cent., Vinag 4.09 per cent., Orgler 2.7 per cent. and according to later statistics, Gräfe 2.3 per cent. This progressive betterment coincides with improved methods of diagnosis and surgical attention, which are most evident in recent years.

Some statistics on abortion are surprisingly high. Flatau in 1907 in a series of 284 cases of ovariotomy, states that abortion followed in 17 per cent. Wähmer reports 22.4 per cent. in a list given in 1905. Flatau says that abortion occurred in 18.03 per cent., but excluding vaginal removal in which 79.1 per cent. abortions appeared, in 237 laparotomies he finds only 6.08 per cent. E. P. Davis gives 49 per cent. following this method. So it is probable that the other high totals were affected by the results of vaginal section.

The method of removal is by laparotomy. Dührssen and some others urge the vaginal route. A fetal mortality of 79.1 per cent. or even of 49 per cent. is prohibitive. Removal of cysts by the vagina is many times a possible operation. There are in our records several cases in which eminently successful results were obtained, but the operation has fallen into disuse because of the traumatism often necessary, the uncertainty of complete removal and in view of the standardized technic of laparotomy no particular advantage to the surgeon is gained or risk to the patient minimized. When performed in the presence of a pregnant uterus it is reasonable to believe that uterine contraction is thereby excited.

Expectant treatment, the tapping of cysts and postponement of operation until after delivery carries with it such danger that these measures must be considered practically obsolete. McKerron's series of 1290 cases shows that 720 were allowed to carry the cyst until pregnancy terminated. Of this number 152 or 20 per cent. died. He says that this mortality would have been greater if some of the cases had not been operated upon during or immediately after labor. When the fetal mortality of 30 per cent. is placed beside Flatau's 6.08 per cent. the conclusions are obvious as to the proper course of treatment.

Even under extraordinary conditions a favorable result may be expected. A woman of twenty-two, after two years of married life, was confined. Soon after delivery pain in the right pelvis and fever called

attention to a swelling in the right groin. Incision opened an abscess which was supposed to have formed in the inguinal glands. She recovered with a discharging sinus. One year later she reappeared, pregnant three months, with a palpable mass to the right of the uterus. Laparotomy revealed a large abscess of the ovary which was removed. The left tube and ovary were normal and a drain led up through the fistulous opening. The operation was without ill effect and she went to full term.

Such experience suggests that given hospital facilities and care, that most ovarian pathology may be successfully met, and that fatal results will be due to special circumstances wherein the tumor has not been found until late, or changes have so advanced that the operation assumes the nature of an emergency. Solid tumors depending upon size and the great chance of malignancy may also influence the prognosis.

Operation in the last month of pregnancy presents a test of surgical judgment. Williams and Hirst advise that Cesarean section be performed in order that the abdominal wound may not be subjected to the strain of labor so soon after a major operation. Hysterotomy is gaining a wider field of application by reason of closer attention to details of procedure and there is no question but that its performance causes less risk than the attempt at forcible delivery alongside the tumor. Instrumental dilatation and forceps delivery immediately preceding laparotomy is justifiable if it is found that the tumor occupies a position high in the abdomen and the chance of rupture small. Some writers believe it justifiable when the tumor is distinctly cystic and plainly evident, to tap the cyst expecting to remove it within twenty-four hours following delivery. The character of the fluid withdrawn will determine whether postponement of cyst removal is proper, as temporary soiling of the peritoneum with serous fluid has but little effect in producing inflammation of a serious nature.

While it may be concluded that ovarian conditions complicating pregnancy are not often seen, the treatment, in removal by abdominal incision as soon as diagnosis is made, is positively indicated. The possibility of the existence of this complication should lead to an early and systematic examination of all pregnant women in order that the accidents of the carrying period and the serious problems at term may be obviated.

REFERENCES.

Carstens, J. H.: Fibroid Tumors Complicating Pregnancy, Am. Jour. Obst., 1909, lix, 447–462.

Lobenstine and Waldo, Ralph: Fibromyomata of the Uterus Complicating Labor Pregnancy and the Puerperium. A Study Based upon One Hundred Cases at the New York Lying-in Hospital, Tr. Am. Assn., Obst. and Gynec., 1911, ii, 371–398.

Lynch, F. W.: Fibroid Tumors Complicating Pregnancy and Labor, Am. Jour. Obst., 1913, lxviii, 427–450.

SURGICAL DISEASES OF THE MALE GENERATIVE ORGANS.

By OSCAR E. NADEAU, B.S., M.D.

ANATOMY OF THE PENIS AND URETHRA.

Penis.—The penis is a pendulous, cylindrical organ arising from the perineum at the symphysis pubis, which varies greatly in size. It is covered with a thin, distensible skin and fascia, and consists of three parts—root, body and head.

The proximal end is attached in the depths of the perineum, where it is made fast to the pubic bone by the suspensory ligament and the crura. The suspensory ligament is a sort of sling composed of elastic fibers, which are attached above to the anterior surface of the pubic bone and pass into the linea alba. These fibers also surround the corpora cavernosa and corpus spongiosum, and are continued downward to become fused with the perineal raphé. The crura are the attachments on each side of the corpora cavernosa to the ischiopubic rami.

The body of the penis is made up of three large cylindrical bodies—the two corpora cavernosa to each side and the corpus spongiosum placed beneath them. These bodies give the organ an approximately cylindrical shape.

The corpora cavernosa are two parallel fibrovascular bodies, cylindrical in shape, varying in length from 15 to 21 cm., according to their degree of erection, and occupying the antero-superior portion of the organ. They are attached to the pubic rami by their proximal extremities, the crura. Each consists of erectile tissue provided with large spaces capable of being distended by blood. They lie in close contact, separated only by a single septum, which is pierced by many openings to allow free communication between their respective blood spaces.

The corpus spongiosum is a cylindrical body, 12 to 16 cm. in length, very similar in structure to the corpora cavernosa, but with smaller blood spaces. It is traversed in its longitudinal axis by the urethra, which lies a little closer to the superior surface. The proximal end is dilated into a pear-shaped bulb, with a base pointing downward and backward. The distal end is composed of a conoidal enlargement, called the glans, which is perforated by the urethra and its distal extremity, the external urinary meatus.

The foreskin, or prepuce, is a cuff of loose tissues surrounding the glans, which is composed of a continuation of the sheaths investing the body of the penis. The innermost layer of skin is brought into

contact with the surface of the glans, and these two opposed surfaces assume the characteristics of mucous membrane.

Urethra.—The urethra in the male is the passageway for both the urinary and genital system. It consists of a tube beginning at the internal meatus in the bladder, traversing the entire length of the penis and ending at the external urinary meatus in the glans. Clinically the urethra is divided into two portions—the anterior portion extending externally to the triangular ligament and the posterior portion between the bladder and triangular ligament.

There are three anatomical parts—the penile, membranous and prostatic. That portion of the urethra beginning at the bladder, passing through the prostate and ending at the posterior layer of the triangular ligament, is the prostatic urethra. It is about 3 cm. long and varies in diameter. At the internal meatus it has a caliber of 35 F., in its middle portion 45 F., and at the triangular ligament about 30 F. It is into the prostatic portion of the urethra that the ejaculatory ducts and Cowper's glands empty.

The membranous urethra lies between the anterior and posterior layers of the triangular ligament. It is about 2 cm. in length and its inner portion curves downward and the outer portion upward as it passes under the ligament. The entire membranous urethra has a caliber of about 27 F.

The penile, or anterior, urethra is that portion extending from the anterior layer of the triangular ligament to the external meatus, and is a tube lined by a very delicate mucous membrane. It has a pouche-like dilatation at each end, the bulb at the inner end, with a diameter of 35 F., and the fossa navicularis, which is an expansion just back of the meatus, with a caliber of 32 F. The external meatus is the narrowest in diameter of the entire urethra, allowing the passage only of a 20 F. to a 27 F. sound.

SURGICAL DISEASES OF THE PENIS.

Injuries.—Injuries to the penis are an uncommon occurrence, and usually occur either during erection or from rapidly moving missiles. During the European war several cases of injury from bullets and shrapnel were reported. When the sheaths of the corpora cavernosa are ruptured and the corpora injured there is fracture of the penis. The symptoms are severe pain and great swelling of the organ from extravasated blood. Rupture of the urethra and retention of urine are common complications.

Treatment consists in applying a large, moist, antiseptic dressing and allowing for absorption of the extravasated blood. If there is fracture, with rupture of the urethra, the treatment is operative. The wounded part should be freely laid open, the urethra repaired, blood clots removed and the sheaths of the corpora carefully sutured. If the last procedure be not carefully executed, there is liable to result an alteration in normal erection. This serious result is best prevented by careful suturing at the time of accident.

MALFORMATIONS OF THE PENIS.

Phimosis and Paraphimosis.—Phimosis may be either congenital or acquired. In this condition the prepuce cannot be retracted freely over the glans because it is too short or its opening is too small, or there are adhesions holding it down to the glans. These cases usually come to the surgeon, because (*a*) the preputial orifice is so small there is no retraction possible, with retention of urine at times resulting, or (*b*) when it is retracted there is difficulty in getting it back. The treatment is circumcision.

Circumcision.—This operation may be performed in different ways, but the following procedure is the one that the writer follows: All adhesions between the prepuce and glans are first carefully liberated with a blunt dissector or grooved director. With the organ lying in its natural position a large hemostatic forcep is applied to the end of the glans over the loose skin. The forceps are carefully closed, allowing the glans to slip back, but catching the redundant prepuce. That portion projecting beyond the forceps is cut off and the forceps removed. This incision removes the cutaneous portion of the prepuce, but does not excise enough of the mucous membrane, which must be slit up the midline of the dorsum to the corona. The entire mucosa, except 0.5 cm. attached to the corona, is excised and the small arteries caught with hemostatic forceps and ligated with very fine catgut. It is very important to stop all bleeding before proceeding with the operation, as troublesome hematoma may ensue. Fine, interrupted catgut sutures are now applied to approximate the mucous surfaces, so as to secure primary union everywhere. It is usually sufficient in young children to place one suture on the dorsum, one on the frenum and two on each side. In adults, however, the stitches should be about 4 mm. apart.

After-treatment.—These wounds will heal well without any dressing but, on account of the irritation of clothes, it is best to apply a vaseline dressing with a flap of gauze covered with vaseline so strapped above the pubis as to allow of its being elevated during micturition. Children should be kept in bed during the first few days, otherwise the friction of the clothes against the wound may cause pain.

Hypospadias.—During embryonal life there are two halves of the urogenital structures which normally come together in the midline along their entire extent. This development may be incomplete or arrested at any point of the growth, in which case deformities of the penis and urethra occur. Hypospadias is an anomaly in which all or a part of the urethra is absent. The condition is evidenced by an opening in the midline which may be (*a*) just posterior to the corona, (*b*) anywhere along the length of the penis, (*c*) in the scrotum or (*d*) in the perineum. Along with the shortened urethra there is usually a varying degree of penile deformity. In the mild cases, with meatus near the corona, there may be no other deformity. The shorter the urethra becomes the more likely is there to be an accompanying bend-

ing or bowing downward of the organ. In the penoscrotal and perineal varieties the penis is often very small and sometimes cleft. This condition is often mistaken for that of hermaphroditism.

In a large proportion of cases there is a dimpling or pouching of the end of the glans where the normal urethra should be. At times one is fortunate enough, from a surgical standpoint, to have a blind urethra extending from the glans to a point very near the patent opening.

There is often found a family tendency to this deformity. Carl Beck records three brothers in one family, all with scrotal hypospadias two of which he operated upon. The same author quotes that Rigaud Frank found this abnormality in every member of a family in several generations, while Sepelletier relates the case of two brothers with scrotal hypospadias. It was thought in the early days that intermarriage was the cause of the deformity.

Symptoms.—Patients come to the physician usually because the stream of urine, instead of following the direction of the penis, takes a downward course. These boys must necessarily either soil their clothes or squat down when they urinate. The condition is then brought to the attention of the parents, who naturally seek advice. In some of the cases, however, the abnormality is not discovered nor brought to the attention of the physician until the time of puberty or just before contemplating marriage. It is then that it may be noticed that coitus is impossible or that the man is sterile. The mental state of these cases, with the great attendant anxiety and worry, does not allow them to act normally in society nor to enjoy life as they would wish.

Treatment.—The surgical treatment of hypospadias varies greatly with the degree of malformation. As a rule the greater the malformation, or in other words, the nearer the opening is to the perineum, the more extensive must be the plastic work. It is also well understood that the chances of failure of surgical intervention increase with the degree of malformation. The reason for these failures is that the urethra or the flaps used in making the new channel must be put on greater tension because less tissue is available. This tension of flaps and of sutures results in necrosis and fistula formation, often making the condition far worse than it was before operation. Cicatricial narrowing of the urethra and a tortuous organ arising from contraction of fibrous tissue must also be guarded against.

To prevent operative failure the one great principle of plastic surgery must be constantly kept in mind, *i. e.*, in selecting a flap to cover a defect this flap must be cut much larger than the defect and no tension must be applied in attaching its edges. With this principle constantly in mind during the course of a given operation the chances of a reasonably perfect result are much better.

There have been a large number of surgical operations devised and used for the relief of hypospadias. Some of the methods have been successful, or partly so, only in the hands of their originators, while other operations are more or less successful with a larger number of

workers. In this monograph only those methods which have cured the deformity in a large proportion of cases and by different men will be described. It is, of course, necessary that one has the natural aptitude and patience required to do this most tedious type of plastic surgery.

In all of the operations it is well to make a perineal urethrotomy through which a retention catheter is inserted, which is kept in place until the wound has healed. Neglecting to take this precaution frequently results in failure unless all of the stiches in the plastic operation are so closely and carefully applied that no leakage results. While the retention catheter is in place, Ochsner recommends the giving of 5 minims of aromatic sulphuric acid in distilled water, every two or three hours, in order to prevent the accumulation of earthy phosphates in the catheter. The dose must, of course, be regulated according to the age of the patient.

Another precaution which it is important to take into account in all of these operations is the fact that in many cases a satisfactory ultimate result can be obtained much sooner if the operation is carried out in a number of stages and if these stages are not hurried. One frequently loses what has been gained by a little too much haste. It should also be borne in mind that considerable edema is to be expected and that due allowance must be made in order to prevent pressure or tension necrosis. In older boys and in men, erection must be anticipated after the operation. For this reason it is a good plan to give bromides during the after-treatment.

Treatment of First Degree of Hypospadias.—In this class of cases there is a somewhat shortened urethra, with the orifice in the midline of the ventral surface near the corona. There is little or no deformity of the corpora cavernosa nor glans, and usually a dimpling in of the glans is present where the meatus should be. This is the most satisfactory kind of case to treat surgically; also it is the type that needs surgical intervention the least.

The best and simplest technic is that devised by Beck and Hacker and used extensively by C. H. Mayo. It consists of a dissection of the urethra, beginning with a wide cuff about the meatus and extending along the urethra for an inch or more, then bringing this loosened and lengthened tube through a tunnel in the glans made with a trocar. The technic in detail of this operation follows:

The patient is anesthetized (general anesthesia) and a rubber tube constrictor placed about the base of the organ, just sufficiently tight enough to shut off the venous and arterial flow. The entire region is then cleansed and the field prepared aseptically. An incision is made through the skin from the orifice to a point about half-way the distance to the scrotum. The skin flaps are then dissected to either side. The incision around the urethra is carried to about a quarter of an inch in a circle and the skin dissected loose to the urethral opening. This dissection is then continued around the urethra the entire length of the original skin incision, great care being taken to include a thick cylinder

of tissue around the mucosa of the urethra. This part of the operation requires unusual care because the delicate mucosa may easily be perforated with the knife. As a result, we now have a thick urethra dissected free for a distance of about 3 cm., besides a cuff of mucous membrane about the orifice, which allows of an increased length of about 1 cm. In other words the urethra, with its cuff of excised mucosa, is 1 cm. longer than it was.

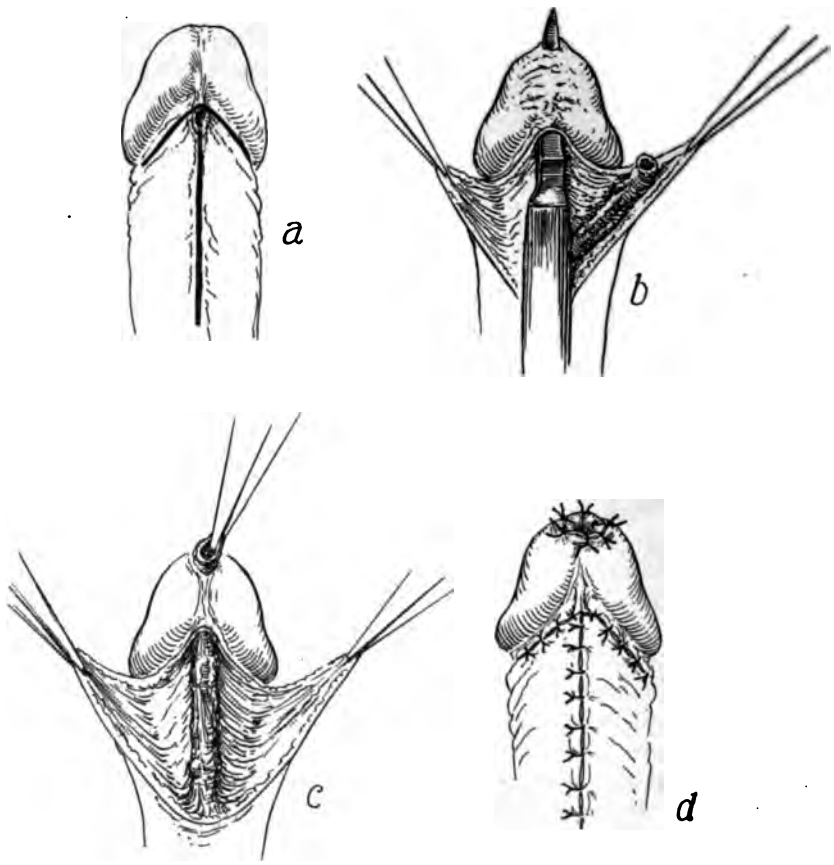

FIG. 216.—The Beck-Hacker operation for hypospadias. *a*, the line of incision; *b*, isolating 2 inches of urethra and making the new opening; *c*, the urethra pulled through the new opening; *d*, application of stitches.

The glans is next transfixed in the direction of the urethra by means of a sharp trocar 4 to 5 mm. in diameter. This opening should be placed a few millimeters above the small dimple in the center of the glans, which marks the point at which the meatus was normally intended, because if this is not done the organ will curve downward and produce an uncomfortable deformity. A pair of fine hemostatic forceps is then passed through the canal made in the glans and the

urethra drawn through. The edges of the urethra are next sutured to this new meatus by means of fine horse-hair or silk stitches, care being taken to allow enough of the urethra to project to overcome the resultant retraction during the after-healing.

In order to close over the defect where the urethra and its cuff have been excised it has in the past been the rule to bring the skin flaps together in the midline. This procedure, however, sometimes results in fistula and scar formation, with bowing of the organ. It is a better plan to cover the defect with a free flap from the usually redundant prepuce. This flap may have one or two pedicles in its construction and find silk or horse-hair is used to coapt the edges. By using this method with great care one may hope to secure an excellent result in almost every case.

Treatment of Penile Variety of Hypospadias.—In this condition the urethra is considerably shortened with its opening anywhere from the corona to the penoscrotal junction. At the same time there is marked deformity of the organ in general, consisting of a shortening and bowing downward. In the state of erection there is a relative shortening of the urethra, thus causing greater bowing, which is a very common complaint of the patients. In these cases the urethra must be lengthened at least an inch by plastic operations.

Many methods have been devised for this condition, with varying success. Many forms of plastic operations, using the foreskin, the skin over the shaft, or even a vein or an appendix for the new urethra, have been developed. Carl Beck,[1] however, who has had a large experience with these cases, and who had tried many different operations, now makes use of a technic which he devised. His description of it follows:

"We begin by separating the orifice of the urethra from the glans and place it where it actually belongs. We take the glans between our two fingers and incise transversely immediately above the orifice while pulling the glans upward. The borders of the transverse incision separate and form a rhomboid defect (Fig. 217). This rhombus will gradually become larger and larger until it finally measures about an inch and a half to two inches in length and the opening of the urethra will be situated then at the root of the penis.

"We have now to cover the defect, which has the shape of the rhombus, with a flap which can afterward be used also to the formation of the urethra. For this purpose we employ best the prepuce. This is done in such a way that the prepuce is raised and transfixed with a scalpel. The incision is enlarged laterally enough that the glans is pulled through this opening. The flap which forms, and which has on two sides its connection with the prepuce, is sutured on the two ends. Such a prepuce, if spread out, makes very good material for this purpose, and the pictures (Figs. 217 and 218) show how beautifully this can be accomplished and how nicely it heals. We are then in a position to

[1] Surg. Gyn. and Obstet., xxiv, No. 6, 530–531.

form a new urethra, about an inch and a half long, a tube wide en to act as urethra.

"In the first operation we do not need to make a by-pass of u we can fasten the corpora cavernosa with adhesive plaster ove

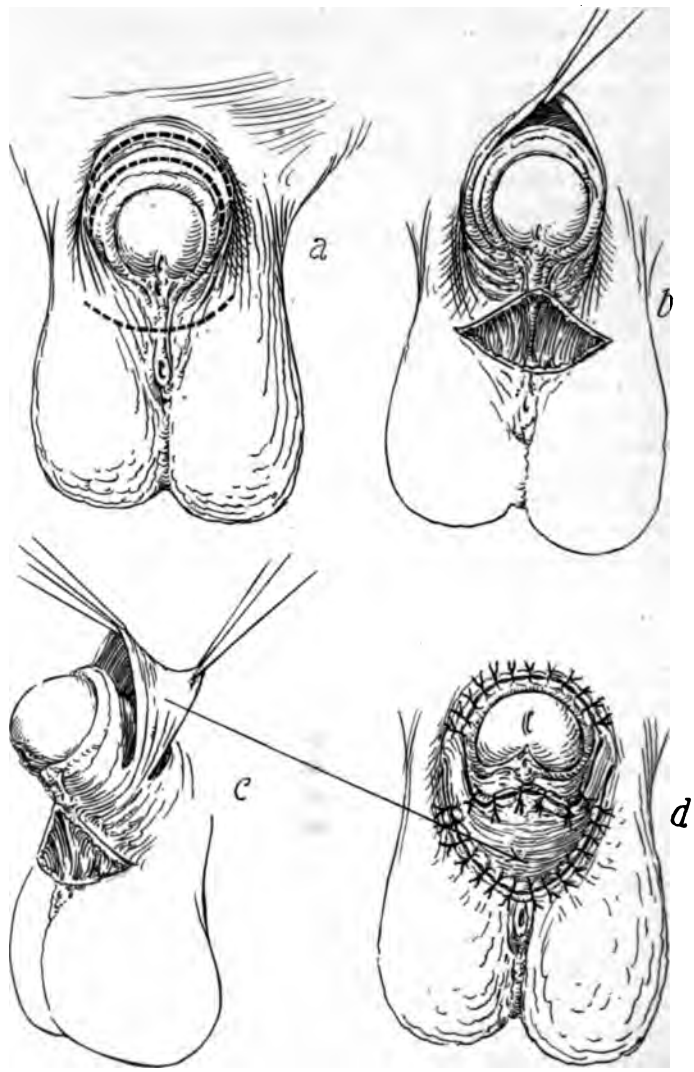

FIG. 217.—The Carl Beck operation for second degree hypospadias. *a*, incisions ridge; *b*, freeing the urethra; *c*, freeing of a portion of prepuce; *d*, the prepuce b down and sutured to form the base of the new urethra.

pubis, and in that way prevent soaking of these wounds with Should we have to deal with a sensitive or very unruly patie a child, it might be well for two or three days to use a cat

(*á demeure*). We leave the prepuce flap in connection with the surface of the corpora cavernosa long enough to produce a good, solid union, which takes, as a rule, in three or four weeks. After this has become established we begin with the formation of a tube by simply making

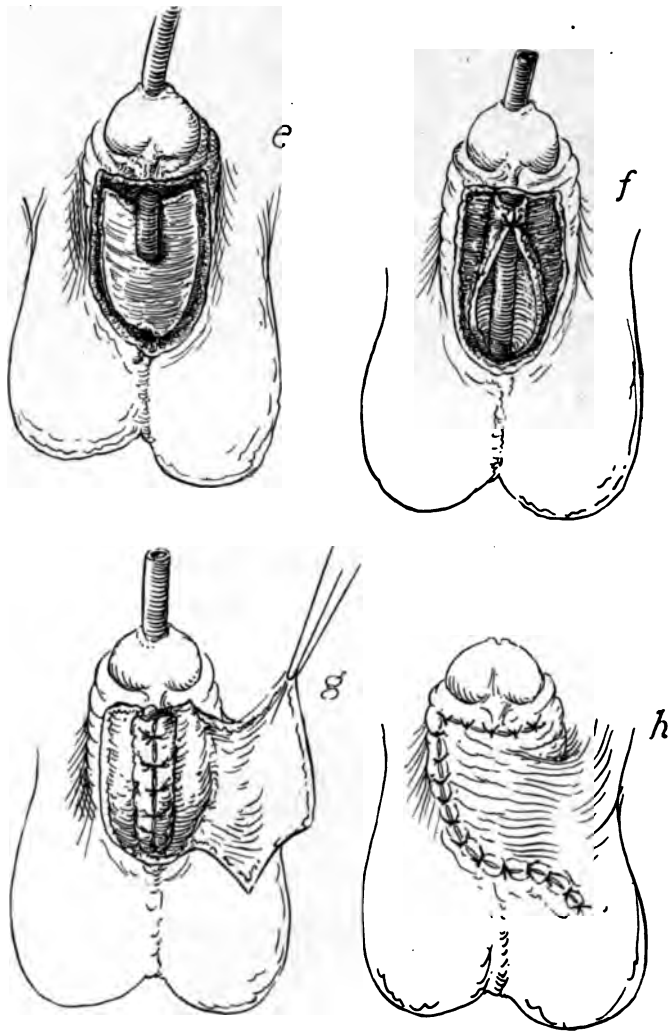

FIG. 218.—The Carl Beck operation for second degree hypospadias. *e*, second stage of operation, forming an inner urethra by dissection; *f*, inner urethra being sutured about a rubber tube; *g*, dissection of a flap from the scrotum, ready to cover the urethra; *h*, ultimate result of the operation.

on both sides a long incision, uniting over a large-sized rubber catheter the two borders of the wound and separating the skin of both sides far enough to allow a good union of the outer surface of the skin (Fig. 218, *e* and *f*).

"As suture material I used catgut formerly, but found that the finest catgut was not as good as horse-hair; interrupted stitches tied into the urethral tube and cut very short answer and give the best union.

"At this time we use the natural urethra without a catheter, leaving a fistula at that point where our newly formed urethra starts, namely, at the root of the scrotum. Wound-healing is always very satisfactory, and, to our surprise, we have noticed that after wound-healing has taken place, notwithstanding the presence of the fistula at the root of the scrotum, the urine, to a great extent, passes through the newly formed urethra. We are then in the same position we would be in if we had to deal with a result of an external urethrotomy. Our difficulty is easily overcome by simply freshening the borders of the fistula and letting it heal out. Sometimes the individual steps of operations are not very successful. It takes two or three attempts, but ultimately we have a good union and a substantial urethra, about two inches in length and wide enough, as the pictures will show. The patient urinates in a full stream through the newly formed urethra, and in case of an erection there is absolutely no scar formation or pulling (Fig. 3, *g* and *h*)."

In the penoscrotal or perineal types of hypospadias there is much greater deformity and the results by different workers have been almost universal failures. Hence, a description of the operation is worthless.

STRICTURE OF THE URETHRA.

Stricture of the urethra is one of the most common surgical conditions encountered in the male genital organs. It is also sometimes one of the most unsatisfactory conditions to treat surgically. (A discussion of the causes and diagnosis of strictures is given on page 691, *et seq.*)

Treatment.—When a stricture will allow of a sound from 14 to 20 F. or larger to be passed one can frequently keep the passage open by the repeated use of sounds in gradually increasing sizes, used at first every two or three days, later once a week, and then once a month for several years. Whenever the stricture can be kept open sufficiently to relieve the patient by this means it is always better than the use of other and more drastic measures.

In cases of small-calibered urethra the treatment by sounds is often not satisfactory, because, although the urethra may be dilated with the sound, it has a tendency to contract within a rapidly short time after instrumentation. It is frequently possible to release the back pressure of urine by hot baths given twice a day for several days previous. A release of urine may also be obtained by passing a small filiform sound and attaching it in place. This may allow of the urine to trickle past the sound and gradually empty the bladder.

Surgical Treatment of Strictures.—INTERNAL URETHROTOMY.—The most satisfactory treatment of urethral stricture not amenable to the forms of treatment outlined above is that of internal urethrotomy whenever the method is possible. The final results are always more

satisfactory than external urethrotomy, and so it is the operation of choice whenever it can be used. The indications are: (1) Any passable stricture anterior to the bulbus urethra; (2) strictures of the posterior urethra that are easily passable with the urethrotome. However, as a rule this method should be used only in the anterior urethral types.

Technic.—In small calibered lesions a filiform sound is first passed then a "follower," to the outer end of which is attached one of the urethrotomes to be described. When the caliber is not small it is not necessary to use the filiform or the "follower." The two forms of instruments most used and most satisfactory are the Otis urethrotome and the Maisonneuve urethrotome. The latter is best suited in cases with small caliber.

The location of the structure having been previously determined, the knife is placed in its concealed position and the instrument passed into the urethra about 1 cm. farther than the stricture, with the knife in the anterior median line. It is then withdrawn slightly and raised from its concealed bed, cutting the mucosa and submucosa in the region of the narrowing. The knife is again concealed and the instrument withdrawn. When there are several strictures they are all sectioned one after another, starting from within outward. A large-calibered sound, preferable from 30 to 35 F., is next inserted very carefully into the bladder and left in place for about ten minutes and removed. On account of the large amount of hemorrhage often resulting, especially in the cases of deeper stricture, it is well to insert a large-sized rubber catheter, which is kept in place by means of adhesive strips for from twenty-four to forty-eight hours.

The after-treatment consists in irrigating the bladder through the catheter, at frequent intervals, until it is removed, giving urotropin, and passing large-calibered sounds, at first every two or three days, later once a week and finally once a month for from one to five years or even during the entire life of the patient.

EXTERNAL URETHROTOMY.—External urethrotomy or perineal section is used whenever internal urethrotomy has not been feasible or has failed, due to strictures complicated by extravasation of urine or perineal abscess or to impassable strictures. External urethrotomy is usually favored also in strictures of the bulbar portion and is practically always necessary in traumatic rupture of the urethra. The technic of external urethrotomy may be very simple or extremely difficult. By using a guide in the urethra at the time of operation, introduced as far as it will go, one has a far greater chance of success than when no such guide is used. On the other hand, when during an operation the internal end of the urethra cannot be found, it is sometimes necessary to introduce a small probe in the internal portion of the urethra through a suprapubic cystotomy.

As a rule this operation should be done under full general anesthesia. An inverted Y-shaped incision is made with the center at the central point of the perineum, one leg coursing anteriorly in the midline

toward the base of the scrotum and the other two legs toward each tuber ischium. The incision is carried through the superficial tissues down to and through the central tendon and its attached muscles and the external sphincter retracted posteriorly. The central tendon is then incised down to the grooved sound or whatever guide it has been possible to introduce into this portion of the urethra. The strictured portion is found and slit open longitudinally, providing the lumen of the urethra is fairly straight and continuous. In case the urethra has been twisted into an "S" shape or is so involved in adhesions as to make it impossible to free it, or where the two ends are entirely separated, it is then necessary to do some form of plastic operation. A principle to keep in mind always in these cases is to preserve, if possible, some portion of the mucous membrane in its continuity, because the urethra will then have a line of direction for healing which will allow of more rapid and usually more satisfactory convalescence.

When it has been necessary to section the entire circumference of the urethra some portion of the mucosa should be sutured together with fine catgut stitches. This procedure at times requires a plastic operation in order to lengthen the two portions enough to bring them together. A catheter is then introduced through the urethra into the bladder and the remaining portion of the wound permitted to heal by granulation. A complete union of the urethra in these cases can be accomplished much more rapidly and perfectly if the entire circumference is not sutured at once at the time of the first operation.

After-treatment.—The retention catheter is left in place until the urethra has apparently completely healed. The catheter must be left in place for at least a week. It may then be removed and the perineal wound allowed to heal. The after-treatment is the same as that described under internal urethrotomy.

AMPUTATION OF THE PENIS.

Although carcinoma is by far the commonest tumor of the penis, there are other tumors occasionally found which require treatment. Among these are subcutaneous lipomata, fibromata of the corpora cavernosa, angiomata and sebaceous and dermoid cysts, all of which require simple excision only. So-called osteomata, but rarely found, are not true bony tumors, but infiltrations of calcium of the corpora. Papillomata may occur, especially about the corona, and are treated by excision, with cauterization of the base. When there is the least susicion of malignancy, however, especially at the age of thirty-five years or over, such tumors should be treated as malignant, since palliative measures may be just enough stimulation to change the tumor from a benign to a malignant growth. Condyloma is a condition simulating both benign and malignant papillomata, and should be treated in the same way as papillomata.

Malignant Tumors.—Sarcoma is a comparatively rare condition found in this region, occurring only in about 2 per cent. of all malignant tumors. In the experience of many men who have had numbers of

carcinomata to treat they have never seen any other malignant tumors. Those that have been described are usually melanotic sarcomata, resulting from pigmented areas or moles.

Carcinoma is by far the most common tumor found in the penis. It occurs in men from thirty-five to forty-five years of age, the malignancy usually having an inverse ratio to the age; that is, men in the thirties having carcinomata usually have a much more malignant and metastasizing type than those with tumors when at the age of forty-five or more. These carcinomata are all epitheliomata and there are different kinds of epitheliomata, depending upon the layer of skin from which they rise. A tumor of a basal-celled type usually appears as a shell ulcer with an indurated base and has a tendency to grow inward rather than outward, and therefore to metastasize earlier. One arising from the outer layers tends to grow outward into squamous-celled tumors or papillomata, which in the earlier stages are relatively less malignant. In other words the prognosis is much worse in those cases showing shallow ulceration with infiltration than in those with large hypertrophied masses of tissue extending without but having less involvement of the tissues beneath.

Cancer of the penis of any type in its later stages frequently breaks down and forms ulcers. The corpora cavernosa are rarely attacked first, but are involved only when the growth has infiltrated deeply. As a rule the inguinal lymph glands are the only ones infected; further metastases are not common. It will be remembered that the lymphatics of the penis are arranged in two systems, a superficial and a deep; both intercommunicate freely about the corona and carry lymph from the skin and deeper parts of the inguinal lymph nodes by means of the superficial and deep dorsal channels. These collecting trunks may be single or double, and communicate with each other with more or less freedom. The dorsal lymphatics are infected early in cancer while the corpora cavernosa are only secondarily invaded. When the disease has extended into the deeper portions of the cavernosa and corpus spongiosa the metastases are carried under the pubic arch into the pelvic nodes. Such an infiltration in all cases means hopeless metastases from a surgical standpoint.

Indications for Operation.—There are two methods of choice in removing malignant growths of this organ, namely, partial amputation and complete, radical operation. Because of the fact that epitheliomata of the penis metastasize so rapidly into the inguinal lymph glands it is difficult to determine in what instances one may do an incomplete amputation; that is, amputation of part of the penis alone. Cases that have been treated by this method, in which there has been recurrence, have all succumbed to the disease. Cancer may be found to be operable when the disease is limited to the distal third of the organ. There may in these cases be infection of the superficial lymph nodes through the dorsal lymphatics, but the infection has not yet reached the infrapubic lymphatics. The success of the attempted removal of the disease rests upon the thoroughness with which the infected lymphatics and lymph nodes are dissected out.

Partial Amputation.—If the condition present seems to warrant the removal of only a portion of the organ the following method may be employed. A constrictor consisting of a small rubber tube is stretched and passed several times around the base of the organ and tied in order to ensure a bloodless operation. After the point of amputation has been chosen, and this point, of course, should be as far from the tumor as practicable, the skin is divided with a circular incision 2 cm. nearer the pubis than the point chosen. A sound is then introduced into the urethra and a catgut suture passed around each corpus cavernosa and another around the corpus spongiosum down to but not through the urethra. The presence of the sound in the canal, of course, determines the exact location of the urethra. The sutures are then carefully tied. A circular incision is then carried down to but not through the urethra 1 cm. distal to the point at which the ligatures have been applied. Then the tissues are stripped from the urethra for a distance of 1 cm. distally, where the urethra is severed.

The dorsal artery is caught with hemostatic forceps and ligated. If the elastic constrictor be now removed the stump should be found entirely free from hemorrhage. The projecting portion of the urethra should then be split laterally and carried through a button-hole incision in the anterior skin flap, where it is sutured in place with horse-hair. The skin is then drawn over the stump and a tenaculum applied on each side, thus forming a transverse wound. The edges of the skin are united with horse-hair, thus forming a complete covering for the stump. The arrangements of the flaps at the end of the urethra will prevent the contraction of the canal at this point.

The after-treatment consists in applying a vaseline dressing, allowing the patient to walk the second or third day and controlling the tendency to erection by the use of bromides. The horse-hair stitches may be removed on the fifth to the eighth day.

Radical Operation.—Fortunately the more complete operation gives satisfactory results both as regards permanency of cure and function of the urethra, even in advanced cases. This operation is, however, much more extensive and correspondingly more severe as regards the production of shock. The procedure should involve the removal of the entire organ, together with the scrotum and its contents, the tissues of the spermatic cords and a complete dissection of the inguinal lymph glands. There is also involved a transplantation of the remnant of the urethra into the perineum.

An incision is begun opposite the internal abdominal ring on one side and carried down in the line of the inguinal canal around the lower edge of the scrotum, but leaving sufficient skin to cover the defect after excision of the parts. This incision is carried up on the other side to the internal abdominal ring in the same manner. Another incision above the organ is made just inferior to the pubic bone, with its two ends joining the upper ends of the first incision. These two incisions then bound a crescenteric area. The skin and superficial fascia are dissected upward and all of the lymphatic glands carefully removed.

The spermatic cord is then isolated, ligated at its entrance into the abdominal cavity and sectioned just distal to this point on each side. The bleeding vessels are caught with forceps in order to reduce the loss of blood to a minimum. The suspensory ligament is severed from its attachment to the pubic bone and then the crura are loosened from their attachments to the rami of the pubes.

A sound should next be inserted into the urethra and the latter dissected out to a length sufficient to project ½ cm. beyond the level of the lower skin flap. After isolating this length of urethra it is cut off at right angles and the surrounding tissues loosened as far as the prostate gland. The remnant of the urethra is split longitudinally for a distance of ½ cm. and passed through a small button-hole wound in the midline of the perineum, just beneath the edge of the lower flap.

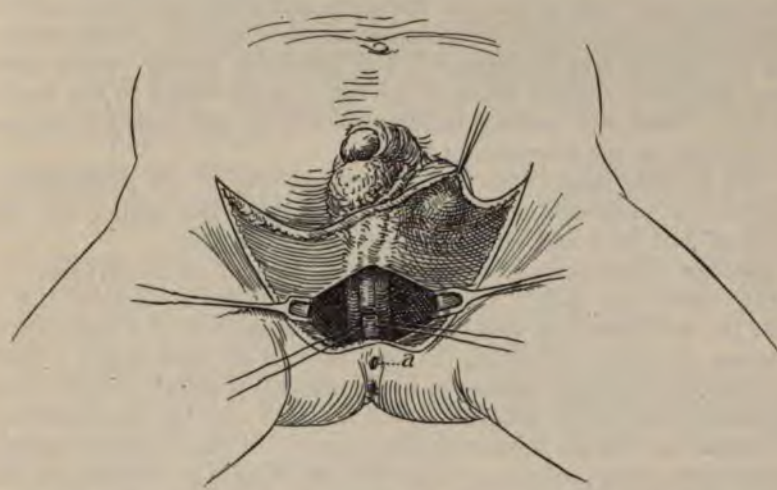

FIG. 219.—An incision for amputation of the penis. The urethra has been divided and the proximal end about to be pulled into the new urethral opening at "*a*".

The edges of the urethra may now be sutured to the edges of the button-hole wound. A small rubber catheter is introduced through the urethra and into the bladder. The entire mass of tissue to be excised is now removed from the perineal muscles and the wound sutured with horse-hair. It is well to leave a small rubber drain in the lower corner of the wound in order to prevent accumulation of serum. An ordinary aseptic dressing is applied and the catheter attached to a rubber tube, the distal end of which is inserted in a bottle hanging to the side of the bed.

Since this operation is usually performed in aged patients it is important that the procedures be carried out as quickly and with as little traumatism as possible. For the same reason they may be permitted to sit up on the next day, since this will not interfere with the healing and will tend to minimize the danger of hypostatic congestion

of the lungs. The retention catheter is removed on the second to third day and the patient allowed to evacuate the bladder spontaneously.

The results of this operation have, on the whole, been very satisfactory, and by the use of a suitable contrivance the patient need not assume the sitting posture in order to micturate. He may carry with him a small metal funnel, flattened on two sides to fit the perineum, and with a spout directed forward.

VARICOCELE.

Varicocele is a varicose dilatation and lengthening of the pampiniform plexus of veins in the spermatic cord. The veins of the testes may also become involved, though rarely.

Anatomy.—The spermatic cord is composed of the vas deferens, the artery and veins of the vas, the spermatic artery and veins and the lymphatics. It is important to remember there are two arteries supplying the testicle and epididymis: The spermatic artery, coming direct from the aorta, and the artery of the vas, a small branch of the vesicle artery. These two arteries anastomose well so that either is capable of carrying on the functions of both.

The anterior group, the spermatic veins proper, are those usually involved in varicocele. The veins on the right side empty into the inferior vena cava and on the left into the renal vein.

Etiology.—Varicocele is almost invariably found on the left side, the right being very rarely affected. An anatomical reason for this is that the left spermatic vein enters the left renal vein at a right angle, whereas the right vein enters the vena cava at an acute angle. There is, therefore, a higher column of blood and less freedom of flow in the spermatic vein on the left side. This, together with the fact that there is pressure on the left vein by the frequently distended sigmoid flexure, would seem to be sufficient reason for this condition occuring on the left side in most all cases. The condition is usually found in boys from sixteen to twenty-five years of age.

Symptoms and Signs.—There are three distinct classes under which all patients may be distributed from a clinical standpoint:

In the first there are no symptoms; the patient discovers the deformity by accident or it is recognized by his physician incidentally.

In the second class he has suffered severely from a dragging pain in the left side of the scrotum, extending into the groin and frequently into the back. This pain is increased when the patient is compelled to stand at his work or lift heavy weights. It is also much more severe when he is tired, especially during warm weather. This is a marked feature of varicocele, that the number of cases regularly increases with the approach of warm weather and decreases in winter.

In the third class the patient is neurasthenic and has attributed many forms of mental and physical suffering to the varicocele. He may suffer physically in the same manner as the patient in the second class, but the prominent symptoms are those of neurasthenia.

Diagnosis.—There is a marked difference upon palpation in the right and left half of the scrotum. On the right side can be distinguished a hard, cord-like structure, the vas deferens extending the entire distance of the scrotum, with the testicle located at its lower end. On the left side these parts are almost concealed by a large accumulation of elastic, worm-like structures coiled upon themselves, giving rise to the sensation which has been compared to the manipulation of a number of angleworms. This is due to the great dilatation of the spermatic veins, which are in a varicose condition.

If the patient is placed in the recumbent position the veins become empty and can no longer be felt unless the affection has existed for a long time, in which case the walls of the veins themselves will have become thickened in the natural tendency of compensation, and then the change in the fulness of the vessels will not so completely alter the impression upon palpation.

Very rarely the condition is present upon both sides, and still more rarely upon the right side alone, because the anatomical difference of the two sides favors the formation of varicocele upon the left.

The malady is so characteristic that it is not likely ever to be confounded with any other.

Indications for Operation.—In the first class operation is plainly not indicated, as the condition is harmless in itself so long as it gives rise to neither pain nor discomfort. It neither causes any other pathological state nor does it predispose to any, hence there can be no good reason for surgical procedure. In these cases it may be proper to advise the wearing of a well-fitting suspensory bandage, which will tend to prevent the further dilatation of the veins.

In the second class surgical treatment is strongly indicated, because if properly executed it will result in permanent relief in almost every case. It can be performed with safety to the patient, and it will disable him from work only a short time.

In the third class it is necessary to determine whether there is any possibility of causal relation between the varicocele and the neurasthenia. If such a relation can be established the operation is indicated. If there is as plainly no relation between the two, then the operation is not called for unless there seems to be reason to suppose that the presence of the deformity causes undue anxiety of the patient, which in turn causes or increases his neurasthenia. In such event the removal of the deformity might remove at least one cause of the neurasthenia.

If there is doubt it seems but fair that the patient be given the benefit thereof and that surgical relief of the pathological condition be employed.

Technic of Operation.—Various operations for varicocele have been devised and used, such, for example, as tight compression, galvanopuncture, resection of a portion of the scrotum and subcutaneous ligation of the veins, but all have given place to ligation of the veins after open incision. A typical and useful method will be described.

An incision 3 or 4 cm. in length is made directly over the spermatic

cord downward from a point just below the external abdominal ring. The bloodvessels which appear in the incision are either caught at once between two pairs of hemostatic forceps and then cut or the incision is made directly down to the tissues of the spermatic cord and the bleeding points then caught with hemostatic forceps.

It is important that throughout this operation all bleeding be carefully controlled, in order to prevent infiltration of the tissues with blood or the formation of a hematoma, for both of these states are exceedingly annoying, not so much on account of their inherent importance as because of the anxiety they produce in the patient.

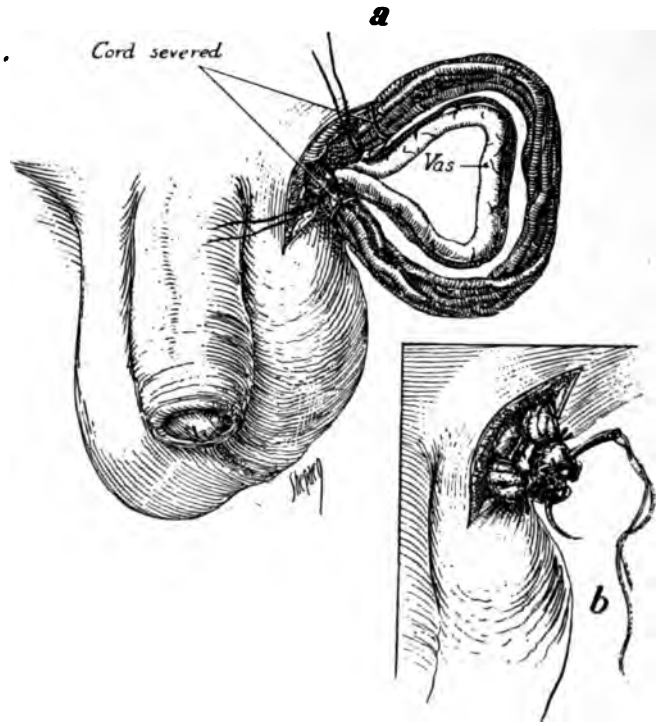

FIG. 220.—Varicocele Operation. A small incision has been made at the upper end of the scrotum and the entire cord brought outside of the wound. The vas together with its small artery and one or two veins is solated from the remainder of the cord which consists of the varicosed veins. A ligature is then placed on the varicosed veins as high up as can be applied with safety. Another ligature is then placed at the lower end of these veins just above the epididymis and the excess of veins removed at the line shown leaving a stump at each end. The insert (*b*) shows the method of suturing the two stumps together after the vas has been dropped back into the wound.

The cord is then brought up into the wound, and the vas deferens with a few accompanying small arteries and veins isolated. This leaves the great mass of varicose veins in a separate mass. After carefully carrying this separation from the external abdominal ring to a point 1 cm. from the testicle the mass of veins is transfixed above and below

with a double catgut ligature and tied in halves. The intervening portion is then cut away, caution being taken to leave a sufficient amount of tissue beyond the ligatures to prevent slipping. The two stumps are then united with catgut sutures, to prevent the dragging down of the testicle, with its subsequent discomfort.

There is some danger of shortening the cord too much, so that the testicle will be drawn up close to the external abdominal ring. This does not give rise to pain, but the deformity may cause an increase in the neurasthenic condition of the patient. If possible the testicle on the operated side should hang only a little higher than the opposite one. It is quite important to have the result both cosmetically and anatomically as nearly perfect as possible.

The deep fascia is then sutured with fine catgut and later the skin. It seems best to suture the fascia separately in order to prevent the infection of the deep tissues from the skin. An ordinary gauze dressing is applied to the wound and held in place by a suspensory bandage. The wound usually heals within a week and the patient is able to perform ordinary work in two weeks.

If one approaches the testicle too closely in the operation the resulting irritation is likely to cause the formation of a hydrocele. In order to prevent this in any case in which there seems such a likelihood it is best to split the tunica vaginalis, evert it and suture it in the everted position before replacing the testicle in the scrotum.

HYDROCELE.

Hydrocele is an accumulation of serous fluid within the tunica vaginalis of the testicle or the spermatic cord, or both.

The cause of hydrocele is not always apparent from the history. Approximately one-third of the cases are seen in boys under seven years of age, the other two-thirds in adults of from twenty to forty years. The most frequent cause is traumatism of the scrotum, seen in 40 to 50 per cent. of instances. The next most frequent cause is gonorrheal inflammation. Occasionally tuberculosis of the tunica vaginalis extending from the epididymis or vas deferens causes a chronic hydrocele.

Congenital Hydrocele.—In infants with a funicular process still patent there is sometimes present a congenital hydrocele which extends along the cord into the abdominal cavity. A frequent complication of this condition is a congenital hernia.

When the entire funicular process is open the fluid can be expressed into the abdomen. In this condition, of course, there is a definite contra-indication to injection of chemicals, such as solutions of iron, iodine and phenol, because of the danger of producing acute traumatic peritonitis, with resultant adhesions. If the hydrocele does not recede spontaneously, as it often does in infants, the only cure is open operation, with complete obliteration of the sac.

Diagnosis.—The physician is usually consulted only after the tumor has attained so great a size that its weight may annoy the patient and even interfere with locomotion.

Aside from the rare occurrence of sarcoma so soft in structure as to simulate fluctuation the only condition with which hydrocele can be confounded is scrotal hernia. This is true especially in children in whom the contents of a hernia frequently give the same impression on palpation as the liquid contained in a hydrocele and in hydrocele of the cord located in the lower end of the inguinal canal and which can frequently be reduced through the inguinal canal into the peritoneal cavity. There is, however, this difference: Hydrocele will always reduce as a solid mass, only to reappear in a few moments without regard to the form of truss that may be applied, while hernia will give the sensation of being composed of loose substance, and it will remain reduced if properly supported by a truss.

In hydrocele of the tunica vaginalis the light test is the most reliable. A small tube is applied to the side of the scrotum, then a light is placed upon the opposite side. If the light is seen through the tube it is an indication that the mass is composed of a sac containing transparent fluid. However, it sometimes happens that the hydrocele is so thick-walled in old patients that no light will penetrate. Occasionally the fluid may not be transparent, being discolored by blood pigments, and then the light test may be misleading.* A very simple test consists in grasping the scrotum, directly above the mass, between the finger and thumb. If the tissues of the cord can be plainly distinguished the case is one of hydrocele; if not, it is a hernia.

Abscesses may be distinguished by the evidence of inflammation; edema of the scrotum, because of edema elsewhere in the body. Tumors of the testicle are usually hard and do not fluctuate.

Occasionally, in old patients in whom hydrocele has existed for a long time, especially if it has been frequently tapped, the walls of the cyst undergo calcareous degeneration, giving the impression of a hard tumor. This has repeatedly been mistaken for sarcoma or enchondroma, a mistake which is quite unfortunate, because it is usually not discovered until after the organ has been removed.

Operative Technic.—In children, tapping usually suffices to bring about a permanent cure. This may be repeated a few times if necessary, and if not permanently successful it should be followed by the injection into the sac, after the latter has been very carefully emptied, of a few drops of 95 per cent. carbolic acid. The cannula of the trocar should be closed and left in place while the carbolic acid is distributed over the entire surface by carefully massaging the scrotum. After a few minutes the cannula should be opened and whatever fluid may have again accumulated, together with the carbolic acid, should be drawn off. In small children 5 drops of a 30 per cent. solution of carbolic acid in glycerin will suffice if the sac has been carefully emptied before this fluid is injected. It does not matter if all of this fluid remains in the sac, as the amount is not sufficient to cause symptoms of poisoning from absorption.

During the entire manipulation the external abdominal ring should be compressed, in order to prevent the introduction into the peritoneal cavity of any portion of the carbolic acid, in case the upper end of the tunica vaginalis has not yet become entirely closed.

FIG. 221.—The Bottle Operation for Hydrocele. A small incision has been made into the neck of the left scrotum and the entire hydrocele sac delivered through this opening. An incision is about to be made through the neck of the hydrocele sac. After the contents of the sac have escaped the sac is turned inside out and the edges of the small incision allowed to come around the cord.

In hydrocele of the cord in children, tapping alone almost always suffices. If this is not the case it is well to make a longitudinal incision, opening the hydrocele and tamponing the cavity with iodoform gauze. After a few days the gauze may be removed and the wound will heal completely in a short time. It does not matter that the inguinal canal is thus left wide open after the hydrocele of the cord which closed it has been emptied and can consequently no longer act as a plug.

During the short period that the child will be compelled to remain in the recumbent position the canal will contract sufficiently to prevent the protrusion of a hernia.

In adults a radical operation is usually advised because it is so simple and so nearly perfect in its results and requires so little time from one's occupation.

About 50 per cent. of cases can be cured by Coley's method of complete aspiration of the sac followed by the injection through the cannula of 15 drops of 30 per cent. solution of phenol in glycerin.

There are two open operations which may be performed with equal success.

The method devised by Jaboulay consists in making a small incision over the upper end of the tumor, splitting the sac, and turning it inside out. The edges are then sutured about the cord so that the smooth endothelial lining of the tunica vaginalis is brought into contact with the raw connective tissues of the scrotum, thus producing adhesions and avoiding the recurrence of fluid.

The "bottle operation" is described by E. Wyllys Andrews as follows: "An anterior scrotal incision is made as in the older methods. The skin should be held tense and the dissection should be nice to the exact layer, which will enucleate the translucent bladder-like mass from the bed. Careful study of the funicular part of the sac is now to be made. Usually a little funnel continues 1 or 2 cm. up the cord. The extreme upper end of this marks the beginning of the cut made into the sac. This cut is vertical on the anterior border and only about 2 cm. long. We enlarge it a little by stretching. Sometimes it is wholly confined to the part over the cord. The incision in the sac is prolonged to its extreme upper end along the cord if the first did not do this. When the sac is emptied it is like a bottle with a small hole at the top. Dilating this slightly with one or two fingers the orifice is held open and the testis is pushed up into it with the other hand. In a moment it can be squeezed through and the whole sac will instantly be everted, with the small button-hole so closely surrounding the cord that it is scarcely visible. It will be seen at a glance there is no possibility of the testis returning into the hydrocele cavity any more than with the suture method."

Great care should be used to secure perfect hemostasis, so as to prevent any postoperative hematoma. The deep fascia is sutured with fine catgut and the skin approximated. A small dressing is applied and a suspensory bandage so arranged as to hold the scrotum well elevated. The wound heals in three or four days and the patient may be allowed to follow his usual occupation a week later. It is well to wear a suspensory bandage for a few weeks after operation.

STRICTURE OF THE URETHRA.

By JOHN H. CUNNINGHAM, M.D.

The definition of urethral stricture is, in a general sense, any narrowing in the course of the urethral canal, irrespective of its cause or character, which impedes the flow of urine through it. More specifically an etiological classification of stricture of the urethra into (1) Congenital, (2) Spasmodic, (3) Organic, (*a*) Gonorrheal, (*b*) Traumatic, is the simplest and most satisfactory classification for the consideration of the subject from the viewpoint of diagnosis and treatment.

In the consideration of the subject of urethral stricture, it should be realized that congenital narrowings, spasmodic stricture, and organic stricture may exist together in the same urethra, and the differentiation and recognition of one from the other forms may be necessary.

CONGENITAL STRICTURES.

Congenital strictures are to be considered as abnormalities. The congenital narrowings of the urethra are dependent upon the fact that the urethra, embryologically, consists of three distinct parts, each developing separately and then uniting one with the other. Faulty union of these three portions results in a varying degree of narrowing at the meatus, the junction of the fossa navicularis with the penial urethra; the penial urethra at its junction with the membranous urethra; and the membranous urethra with the prostatic urethra. Such narrowings, sometimes to the degree of complete obstruction of the canal at one of the above-mentioned points, results in death before or soon after birth.

Congenital strictures are seldom of any real importance from the symptomatic viewpoint. The meatus may be considered as always being the most contracted portion of the canal, and unless extremely small is of little importance other than making it impossible to instrument or examine the urethra and higher portions of the urinary track without first performing a meatotomy. The most important feature of a congenital narrowing of the meatus is with an acquired urethritis, in which event infection may lurk behind it or the other congenital narrowings often associated with a contracted meatus. The train of symptoms dependent upon this condition properly falls under chronic urethritis, where it will be considered.

A contracted meatus, or congenital narrowings at the other points in the urethra are, for the reason of harboring chronic infection, extremely likely to be the sites of organic stricture, provided a gonorrheal urethritis has been acquired. As a congenitally small meatus

prevents an examination of the remainder of the urethra, the meatus should always be cut to the full size of the urethra in order to determine the presence or absence of organic or congenital stricture in the deeper portions of the urethral canal, when any symptoms are present following a gonorrheal urethritis.

Meatotomy.—In performing a meatotomy it should be borne in mind that a narrowing at the junction of the fossa navicularis with the penial portion of the urethra invariably exists in some degree with a small meatus, and should be divided at the same time as the meatus. A bougie à boule, the largest size that may be introduced through the opened meatus, and in the adult should be about 30 F., should be passed down the urethra so that any narrowings not entirely divided at these points may be detected on its withdrawal, and divided so that the bougie à boule has an uninterrupted withdrawal.

A meatotomy is best done under local anesthesia by introducing a novocaine or cocaine tablet, crystals, or powder, into the fossa navicularis, and allowed to remain for five minutes. The incision can then be made with a thin bladed knife, without pain, and should always be made in a downward direction. By placing a pledget of cotton soaked in adrenalin solution between the cut surfaces, hemorrhage is slight, and the pledget may possibly remain in position without being disturbed by urination. It should be removed in twelve to twenty-four hours, if not dislodged by urine. The passage of a bougie à boule, of full size, should be done daily for about a week to prevent the cut surfaces from healing together. If bleeding is severe, as is sometimes the case, it may be controlled by placing a towel over the pubis, placing the penis on it, folding the towel over it, and compressing the glans penis by a belt or bandage, which is only removed when it is necessary for the patient to urinate. Occasionally it is necessary to pass a soft rubber catheter to the bladder and confine the patient to bed, with constant drainage.

SPASMODIC STRICTURE.

Spasmodic stricture is not properly a disease, but a symptom, and is an involuntary contracture of the compressor urethræ muscle sufficient to prevent the passage of urine. It is usually transitory, but sometimes permanent; usually occurs in highly strung, nervous individuals under some exciting or psychical influence.

The transitory type is often observed by the inability to pass urine in the presence of others, which is sometimes overcome by the impulse created by running water, a sitz bath, or a morphia and belladonna suppository.

The permanent type, while sometimes having a psychical origin, may be due to irritating elements in the urine; irritating urethral injections; as a result of the passage of instruments, and is the common result of nerve reflexes from neighboring parts. It is commonly observed as a result of such reflexes produced by the operation for hemorrhoids, hernia, and surgical procedures carried out upon the

genitals. Retention, under the above-mentioned conditions, usually requires catheterization.

Diagnosis.—While the diagnosis of spasmodic stricture is simple when associated with the predisposing causes just mentioned, it is necessary, at times, to differentiate such pseudo strictures from true strictures. Especially is this the case when a patient is observed for the first time with acute retention of urine, with a history of gonorrhea, and it is always to be borne in mind that spasmodic stricture and organic stricture may exist together.

The points of differentiation are dependent upon the realization that spasmodic strictures occur only in the membranous urethra, at the location of the compressor urethræ muscle; that in this condition a full size sound held firmly against the closed area will cause the compressor urethræ muscle to relax, when the sound will pass easily into the bladder, and may be withdrawn without the grasping sensation which is pathognomonic of organic stricture. In some instances, usually when the patient is exceedingly nervous, a general anesthetic may be necessary to permit the passage of the instrument because of the severity of the spasm. With spasmodic stricture, without associated organic stricture, the urine will be absolutely clear, and free from shreds or other products of inflammation which, of course, is not the case with organic stricture. It should be borne in mind that organic stricture is one of the commonest causes of spasmodic stricture, and if there are any pathological elements in the urine, the anterior urethra should be calibrated by a bougie à boule, and the posterior urethra by flexible bougies to detect and locate the organic stricture, if present.

ORGANIC STRICTURE.

Organic stricture, which implies a narrowing of the urethral canal by the formation of connective tissue beneath the urethral mucous membrane, with its subsequent, progressive contracture, is most commonly due to a previous gonorrheal urethritis; over 80 per cent. of all organic urethral strictures being due to this cause. The only other formation of organic stricture is that produced by trauma, most commonly the result of an injury to the perineal urethra by falling astride of some solid object such as a fence or wheel; or a kick or blow to the perineum, thus rupturing the urethra, which, in the repair process, produces a deposit of scar tissue which materially narrows the urethra by its contracture.

Organic strictures, while having an invariable tendency toward progressive contraction, differs in this respect according to their etiological factors and location. Those of traumatic origin contract much more rapidly than those of gonorrheal origin, and strictures located in the deep urethra contract with far greater rapidity than those located in the anterior urethra.

Pathology.—A gonorrheal urethritis producing a chronic inflammation of the urethral mucous membrane and submucous infiltration of

the underlying strictures, often involving the spongy tissue of the corpus cavernosum in one or more areas, and not being absorbed entirely, is replaced by connective tissue thus forming a scar. This scar, with its invariable tendency to contract, materially narrows and prevents the dilatability of the urethral canal usually within one or two years.

Gonorrheal strictures are often multiple because of the activity of the original inflammation at different points in the urethra. Traumatic stricture is usually confined to a single area, due to rupture of the urethral walls at a certain point; but while usually single in number, is more extensive in area.

With urethral stricture, gonorrheal or traumatic, the urethral wall is rigid from submucous scar tissue, and the mucous membrane thickened by proliferation of several layers of squamous epithelial cells, which replace the columnar epithelium of the normal urethra in the repair process. This newly formed squamous epithelium covering the strictured area has a tendency to desquamate and is the common cause of shreds in the urine.

Varieties of organic stricture are described as linear, annular, and tortuous, according to the arrangement of the connective tissue deposit; and as resilient according to its elasticity and tendency to recontract; undilatable and impassable, which terms are simply descriptive of the important physical characters of the stricture.

The location of gonorrheal strictures is most commonly in the bulbomembranous urethra or at a point represented by the peno-scrotal angle. A gonorrheal infection accounts entirely for the strictures anterior to this point, while traumatic stricture may always be considered as located in the perineal portion of the urethra. Stricture of the prostatic urethra can never be considered of gonorrheal origin.

The *progress of contraction* of the urethra depends largely upon the extent of the inflammatory process, and upon its degree of chronicity. Contracture following gonorrhea may be expected within one or two years, if the process has been severe, although the lesion or lesions may not give rise to symptoms before a much longer period has elapsed. As the contraction materially obstructs the outflow of urine; the urethra directly behind the narrowing becomes dilated and loses its elasticity from being constantly stretched by the force of urination; urine is retained in this dilated area, and becoming decomposed, irritates and ulcerates the mucous membrane in this area, and causes a low-grade chronic inflammatory process, which accounts for the gleety discharge at the meatus, usually associated with urethral stricture. Occasionally the dilatation behind the stricture when in the deep urethra may extend to the prostatic urethra, dilating it materially and giving the sense of an enlarged prostate by rectal palpitation, so that a retention of urine in the bladder is sometimes erroneously believed to be due to an enlarged prostate, when the true cause of the retention is urethral stricture.

When the *ulceration behind the stricture* erodes the urethral wall,

ation of urine takes place and abscess formation results in the ethral tissue; and if the urethral opening becomes sufficiently through rupture of the periurethral abscess into the urethra or

FIG. 224.—A filiform stricture in beginning of membranous urethra. X-ray of stricture with argyrol in urethra.

FIG. 223.—Tortuous stricture beginning just beyond peno-scrotal angle. Note dilatation from urethra to behind stricture. X-ray of stricture with argyrol in urethra.

FIG. 222.—Annular stricture at peno-scrotal angle. Note lightness of shadow at point of stricture dependent upon small amount of fluid in the constricted area, and dilatation of proximal portion of urethra. X-ray of stricture with argyrol in urethra.

[1] Tr. Am. Assn. Genito-urinary Surg., 1909, iv.

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FIG. 224.[1]—A filiform stricture in beginning of membranous urethra. *X*-ray of stricture with argyrol in urethra.

FIG. 223.[1]—Tortuous stricture beginning just beyond peno-scrotal angle. Note dilatation from urethra to behind stricture. *X*-ray of stricture with argyrol in urethra.

FIG. 222.[1]—Annular stricture at peno-scrotal angle. Note lightness of shadow at point of stricture dependent upon small amount of fluid in the constricted area, and dilatation of proximal portion of urethra. *X*-ray of stricture with argyrol in urethra.

[1] Tr. Am. Assn. Genito-urinary Surg., 1909, iv.

the urethral ulceration becomes of considerable extent, extravasation of urine results.

FIG. 225.—Annular stricture in anterior urethra with dilatation behind it, and opening of peri-urethral abscess adjacent to it. (Watson and Cunningham.)

Changes in the bladder, dependent upon increasing difficulty in overcoming the resistance in the urethra take place; first as a hypertrophy of the muscular fibers of the bladder wall, diminishing its cavity, and associated with a residual urine and cystitis, and later, if the obstruc-

tion is unrelieved, the bladder wall becomes weak and atonic, the ureters become dilated, and the kidneys hydronephrotic or pyonephrotic.

Symptoms.—While organic stricture, either of gonorrheal or traumatic origin, may exist unsuspected for many years, and the first distressing symptom being complete obstruction of urine, this is not the rule. In the majority of instances a urethral stricture, passing through the cycle of the pathological events enumerated, produces the following subjective and objective symptoms for which the patient seeks advice.

Chronic Urethral Discharge.—The first symptom of stricture, which the patient observes, is usually a persistent urethral discharge of a more or less purulent character, and which is due to the inflammation produced behind the stricture from the decomposing urine retained there after the act of urination. The appearance of such a discharge, in an individual free from it for a considerable period of time following the subsidence of all symptoms of gonorrheal infection, should immediately suggest the presence of urethral stricture, and lead to an endoscopic examination and urethral calibration as well as an examination of the prostate and seminal vesicles and their secretion, provided the smear from the discharge at the meatus is not frankly purulent and does not show abundant gonococci. Dependent upon an inflammation behind the stricture, especially if the stricture is located in the deep urethra, it is not uncommon for the inflammatory process to extend up the ejaculatory ducts to the seminal vesicle and thence to the epididymis producing vesiculitis or epididymitis.

Frequency of Urination is a common symptom and is dependent upon the irritability produced by the dilatation and infection behind the strictured area, with secondary changes in the prostatic urethra and a cystitis. Occasionally, when the stricture is so advanced as to cause a large amount of residual urine in the bladder, frequent micturition may be due to this cause, and if the stricture nearly obliterates the urethral canal, producing retention of urine, dribbling, or incontinence takes place as evidence of an overflow bladder.

Retention of Urine.—In the presence of urethral stricture, well advanced, acute retention of urine is apt to occur at any time, chiefly through indiscretion of diet, producing an irritating urine, or exposure to inclement weather, which produces a congestion about the stricture sufficient to complete the obstruction.

Stream.—A twisted or split stream is often erroneously attributed to urethral stricture and is more commonly the result of the shape of the meatus; yet while little importance may be attributed to a narrowed, twisted or split stream, this feature may be associated with stricture when located in the anterior urethra.

The essential feature of the stream in urethral stricture is that it will have a good projection, which is the reverse to prostatic obstruction. Dribbling of a few drops of urine following the act of micturition is common in spite of the fair projection during the act, and may be explained by the slow expulsion of the last part of the urine from behind the strictured area. Constant straining to overcome the

obstruction not infrequently results in hemorrhoids and occasionally in hernia, which conditions must always be considered symptomatic rather than an entity, and should never receive surgical attention until it is proven that urinary obstruction does not exist. Hemorrhoids and hernia, one or both conditions, are usually associated with urinary obstruction, occasionally with stricture, and almost invariably with prostatic obstruction, if of long standing. Too often these symptomatic expressions of urinary obstruction receive surgical attention and the cause not recognized and left unrelieved, only to have recurrence of hemorrhoids and hernia as a result.

Character of Urine.—The urine may be expected permanently to contain shreds following any urethritis, yet they are always present when stricture exists. The urine will be clear in the absence of any inflammation in the urethra or the co-existence of a prostatitis, seminal vesiculitis, cystitis, or renal infection, and under these circumstances will contain the pathological elements characteristic of such secondary conditions. The presence of crystals or phosphatic deposits in the urine, associated with pain and possibly blood in the urine, should create a suspicion of the existence of prostatic or vesical stone, which are not uncommonly associated with strictures of so severe a character as to produce a residual urine and cystitis.

Pain.—The act of urination is often painful and referred to the perineum, rectum, point of stricture, at the corona, and sometimes in the testicles and along the cord. If cystitis is at all acute, suprapubic pain and vesical tenesmus may be present. If the stricture is advanced enough to cause dilatation of the ureters and kidneys, lumbar pain and other obscure pains of a neuralgic character may be present. On the other hand, pain, associated with stricture is not characteristic, is inconstant and more often attributable to secondary changes.

Sexual Disturbances.—Erections are often feeble, sometimes painful, ejaculations premature from the irritation of the structures of the posterior urethra, associated with erotic ideas, frequent erections and nocturnal emissions. On the other hand various degrees of weakness of the sexual function, even to complete impotency, are observed. The ejaculation of semen is often feeble, due to being retained behind the obstruction, and which feature may be the cause of the inability to impregnate. Frequently no sexual symptoms are present.

Hematuria.—Although not a common feature of stricture, it may be the most prominent and only symptom attracting the patient's attention.

Diagnosis.—It is obvious that the size of the urethra varies in different individuals dependent upon the size of the penis. There is, however, a definite and constant relationship between the circumference of the flaccid penis and the caliber of the urethra, which is known as "The Rule of Otis," who first drew attention to it, giving the figure as follows:

3 inches		30 mm. French scale	
3¼ "	(average size)	32 mm. "	(average size)
3½ "		34 mm. "	
3¾ "		36 mm. "	
And so on		And so on.	

Stricture of the urethra is simple to diagnose. The procedure is not particularly painful, but in nervous individuals it may require local anesthesia, preferably done by the injection of a dram of 1 per cent. solution of novocaine; and held in the urethra five minutes.

One of the most essential features in making the examination for the diagnosis of stricture is to render the canal as clean as possibly by first irrigating the urethra with some mild antiseptic solution, such as potassium permanganate 1 to 4000 or 1 to 5000; for the reason that infection may be expected to exist within the urethra and the manipulations of instrumentation may injure the mucous membrane and thus invite new areas of infection. Failure to do this may result in an active urethritis and systemic infection producing chills, acute suppression of urine and death. The administration of ten to twenty grains of hexamethylenamine, just prior to or after such instrumentation, is to be commended; because every surgeon of much experience with the condition under consideration has probably had the unfortunate catastrophe above alluded to, and every precaution should be taken against it.

The *exploration of the anterior urethra* for the diagnosis of stricture, should be performed by selecting the largest size flexible bougie à boule which will pass through the meatus, and if the meatus is contracted so as not to admit one of 25 F. caliber, a meatotomy should be performed under local anesthesia in most instances before the examination is begun. The flexible bougie à boule which will just pass the meatus is introduced as far as possible, which in a normal urethra will be to the compressor urethræ muscle, or deep urethra. The distance from the meatus of any obstruction encountered should be noted, a smaller bougie à boule selected, until one is found which will pass the obstruction, when it should be passed on until it encounters other obstructions or reaches the deep urethra. By its withdrawal the number and location of the strictures in the anterior urethra may be noted, and some sense as to whether the stricture is plastic or hard may be learned. In place of the bougie à boule the Otis urethrometer may be employed and accomplishes the same object of determining the presence, location, number, and possibly the character of anterior urethral strictures.

The *exploration of the deep urethra* in the absence of very tight strictures in the anterior urethra, is best carried out by the largest size olive-tip flexible bougie which will pass through the anterior urethra, and if a stricture in the deep urethra is encountered, which is impassable to the bougie selected, smaller sizes should be passed until one is found which may be made to enter the bladder, and the caliber, location, and some idea of the resiliency of the stricture thus noted. With the coexistence of a stricture of small diameter in the anterior urethra, little or nothing can be learned of the condition of the posterior urethra until the anterior stricture has been sufficiently dilated; or divided by an internal urethrotomy.

Filiform Strictures.—If the smallest bougie à boule cannot be passed through a stricture in the anterior urethra, smaller sized bougies should

be tried, down even to filiforms. Strictures so tight as to only adn filiforms may be encountered either in the anterior or posterior ureth and in some instances even a filiform cannot be readily passed. Wh

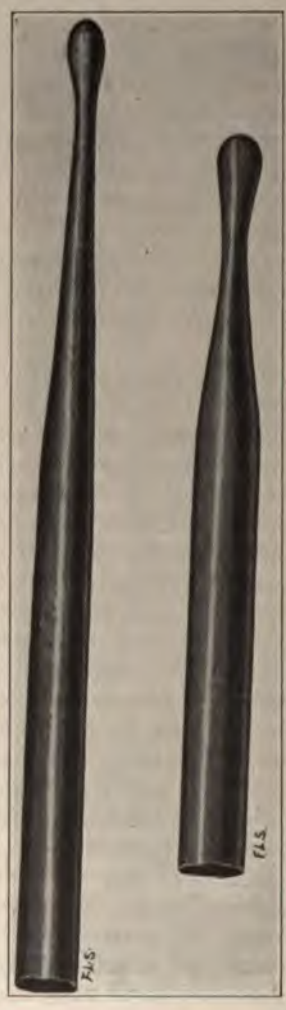

FIG. 226.—Flexible bougies with olive tips. (Watson and Cunningham.)

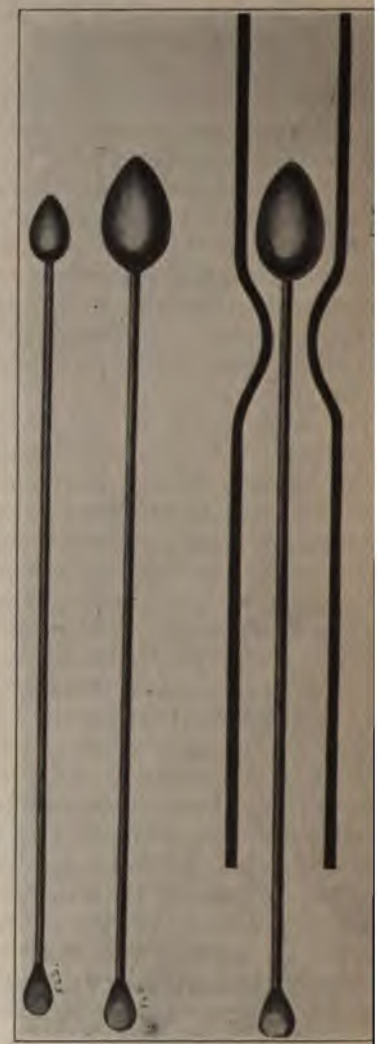

FIG. 227.—Bougie à boule, of differ sizes, shaft made of flexible metal. (W son and Cunningham.)

there is difficulty in getting one of these small instruments by t stricture, it may sometimes be accomplished by introducing six to ei filiforms into the urethra at one time, down to the face of the strictu and by the manipulation of each in turn one may find its way thro

the contracted area. When this procedure is not successful, a dram of a solution of adrenalin, milked backward through the urethra, tends to enlarge the strictured area. Following this a dram of oil should be injected, with the filiforms in place, thus distending the urethra anterior to the stricture, lubricating the narrowed canal and facilitating the passage of one of the filiforms manipulated as just mentioned. If a stricture is encountered which is so small as only to admit a filiform, and one is successfully passed, it should not be withdrawn, but fastened in, which will permit the urine to trickle along beside it, relieve retention, and in consequence of its presence the stricture will be continuously dilated, so that after a few days it may be removed, with a much larger passage in consequence of this continuous dilatation, when bougies of a larger size may be passed, or if an operation is to be done, the guide, which is most desirable as the primary step in the operation, will be in place.

Treatment.—The object of all methods of treatment is to overcome the strictured portion of the canal, and restore it to the normal caliber. The following methods are employed for this purpose:

1. Dilatation.
   (*a*) Gradual.
   (*b*) Continuous.
2. Urethrotomy.
   (*a*) Internal (for stricture of the anterior urethra).
   (*b*) External (for stricture of the posterior urethra).
3. Resection.

Divulsion and Electrolysis are methods which are now discarded for the reason that both have a tendency to ultimately increase the amount of scar tissue, and produce more severe contracture.

1. DILATATION.—(*a*) Gradual dilatation consists in the stretching of the strictured portion of the urethra by the passage through it of successively larger sizes of bougies or sounds; or producing dilatation by the Kollmann dilator, at stated intervals of varying periods of time until the constriction has been dilated to its maximum, which is sometimes up to the normal caliber of the urethra, or even beyond it. In order to accomplish this object the dilatation should be made at intervals of four or five days, unless there is some contra-indication, and after the normal caliber of the urethra has been established the intervals between the sittings may be lengthened until the time at which the stricture begins to recontract is learned. The intervals may then be made a little shorter than that time.

The *duration which strictures will maintain the degree of dilatation* to which they have been carried varies much, and is dependent upon their special character. In the early stages, or when the stricture is not dense or extensive, from four to six months may be frequent enough to maintain the full caliber attained by dilatation; but when the stricture is firm or extensive the tendency to contracture is more rapid and may even require dilatation once a week to maintain them at their maximum degree of dilatation. There are certain strictures in which sufficient

dilatation cannot be attained, no matter how frequent an attempt is made, which cases are properly treated by operation.

For the purpose of gradual dilatation we have recourse to flexible bougies, steel sounds, and the Kollmann dilator.

Flexible bougies are always to be chosen when the stricture is under the caliber of 16 F. for the reason that steel sounds of small size are dangerous, inasmuch as they may be forced through the urethra, producing immediate hemorrhage, subsequent sepsis, and blind pockets or false passages. In the hands of those not skilled in urethral manipulation it is safer to use flexible bougies with strictures of even a larger caliber than 16 F., yet in the hands of those expert the steel sound produces a more rapid dilatation after the stricture has been brought up to this caliber.

The *Kollmann dilator* may be used to dilate strictures which are large enough to admit its passage through them. Its only advantage is that it may be employed without doing a meatotomy when the meatus is of fair size, yet this advantage is, in the writer's opinion, questionable because it is his feeling that the meatus should always be as large as the normal caliber of the urethra. Moreover, the Kollmann dilator is an instrument requiring much care in the way of cleansing; requires a rubber condom, which is perishable; and with this instrument overdilatation is apt to be made, with consequent rupture of the mucous membrane and a portion of the stricture, which is not only a source of immediate pain and discomfort to the patient, but more commonly produces a urethritis and has a tendency to subsequently increase the scar tissue of the stricture. It accomplishes nothing which may not be better accomplished by the passage of bougies or steel sounds.

(*b*) *Continuous Dilatation.*—Continuous dilatation is only to be employed when it is impossible to get anything larger than a filiform through the strictured area. The filiform being fastened in place, the leakage of urine which will take place about it continuously dilates the stricture, so that within a few days the filiform may be withdrawn and slightly larger bougies replaced or gradual dilatation begun.

In some instances when the filiform has been passed, the tunnelled sound may be employed by passing it over the filiform, which acts as a guide, and considerable dilatation immediately obtained; but if much resistance is encountered continuous dilatation is preferable, and the employment of the tunnelled sound is far more often successful if continuous dilatation is employed as a preliminary step.

The *freguency* with which strictures should be dilated varies much, some strictures with little scar tissue can be completely dilated within a few weeks, while others, because of the extensive dense scar tissue, may require months, and some can never be dilated sufficiently to overcome symptoms, and surgical procedures must be employed. As a rule, bougies, sounds or the Kollmann dilator, and preferably the former two, should be passed at intervals of four or five days until the strictured area has been dilated to the full size of the urethra, and sometimes beyond it, as there is a prevalent opinion that overdilatation of the scarred area has a tendency to produce its absorption.

At the successive treatments an instrument two sizes smaller than the largest passed at the previous sitting should be chosen as the first instrument; advancing two sizes at each sitting is a safe rule to follow. Variations, of course, are necessary, corresponding to the distensibility of the stricture dependent upon its character, whether or not the particular stricture under consideration is pliable or not.

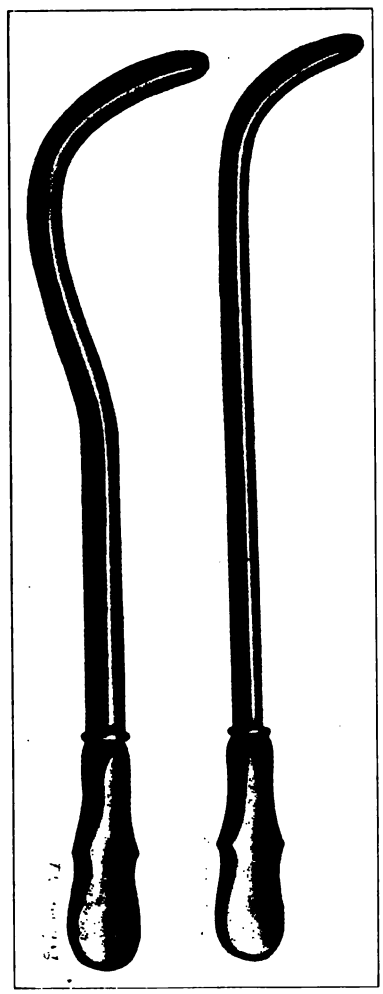

FIG. 228.—Steel sounds of different shapes. (Watson and Cunningham.)

The intervals of dilatation should be lengthened until it is learned how much time is required for the stricture to begin to recontract and the dilatation should then be carried out regularly throughout the patient's life, at stated intervals, in order to keep the urethra at its full caliber.

Rules to be Observed in Treatment by Gradual Dilatati
instrument should be passed in the presence of an active u

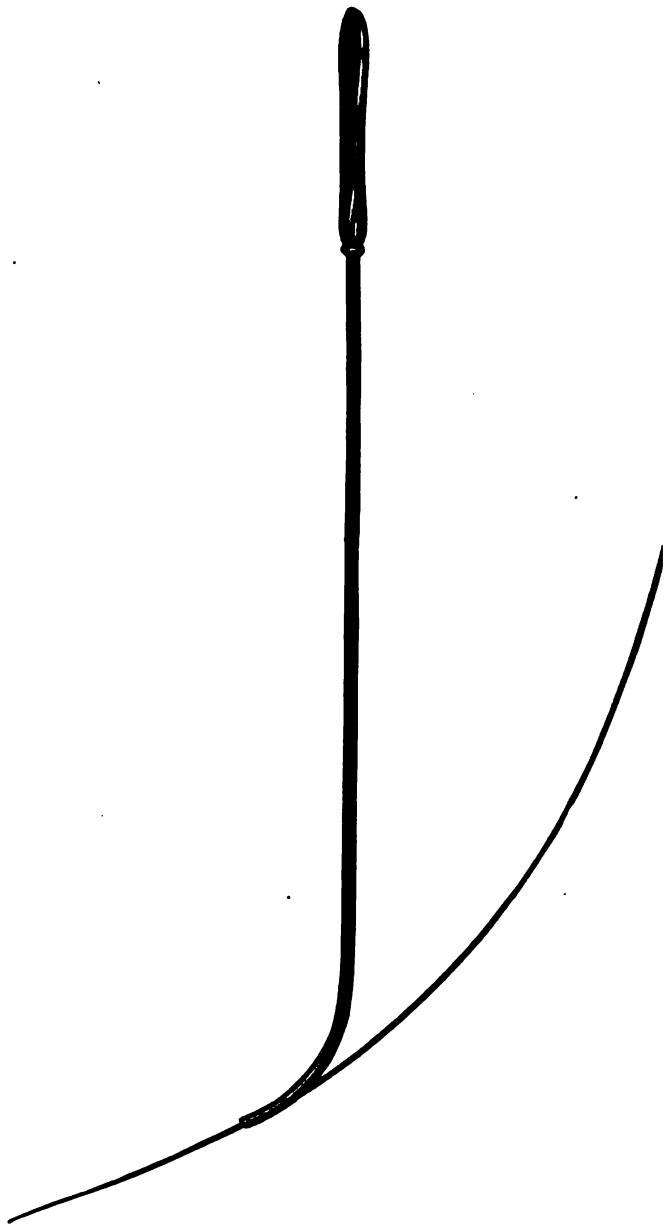

FIG. 229.—Tunnelled sound passed over filiform guide. (Watson and Cur

The urine should always be passed and the anterior urethra
with a solution of 1 to 4000 potassium permanganate prior t
mentation.

The instrument should be sterilized before using; steel sounds by boiling; the flexible bougies by boiling in a strong solution of rock salt, or as an alternative having been cleansed with soap and water, and washed with a weak carbolic acid solution, followed by sterile water, and kept in a formalin atmosphere.

Instruments should be warm when used, and thoroughly lubricated with a sterile lubricant. Flexible bougies should be employed up to the caliber of at least 16° F., when steel sounds may be employed.

During the passage of the instrument movement should be steady, without jerks, gentle and without force, and the organ drawn upward on the instrument and held as straight as possible so that the urethra will not become folded upon itself.

Too much gain should not be attempted at one sitting, and rarely more than three instruments should be passed, increasing two sizes at each successive sitting. An instrument two sizes smaller than the largest passed at the previous sitting should be chosen at subsequent sittings, and with the passage of three instruments the second one should be the size of the largest one passed at the previous sitting, and the last instrument two sizes larger; thus advancing two sizes at each sitting.

Instruments should not be passed more frequently than every third day, and the proper interval is established by the degree of dilatability of the stricture, and the local and constitutional reaction dependent upon the instrumentation.

Gradual dilatation should be discontinued if chills, fever, or threatening symptoms of urinary suppression develops, or if acute inflammatory reaction in the urethra occurs. With the development of such symptoms the appropriate operative procedure is indicated.

The urethra should always be irrigated, preferably with permanganate of potash 1 to 4000, after the passage of the instrument, and ten grains of hexamethlenamine administered.

Spasm of the compressor urethræ muscle, from the mere presence of the instrument in the urethra may take place, and this spasm mistaken for stricture. Especially is this mistake made when small instruments, rather than large, are employed. The spasm can ordinarily be overcome by slow steady pressure against it; applied in the line of the urethra.

In passing sounds the tip of the instrument should be passed as deep as possible before the handle is depressed to force it upward into the prostatic urethra. It must be borne in mind that the prostatic urethra runs parallel with the symphysis pubis, and in order to pass the tip of the instrument to the bladder that the handle must be deeply depressed. The observance of these points, and gentleness are necessary to avoid the making of false passages. If the tip of the instrument does not proceed readily when first beginning to depress the handle, the probability is that the tip is not deep enough in the perineum.

In the passage of sounds subsequent to an external urethrotomy every endeavor should be made to keep the tip of the instrument on the roof of the urethra, as the floor of the urethra has been injured by the incision into it.

2. URETHROTOMY.—The treatment of stricture by a surgical operation is indicated in any stricture, wherever located, if it is so dense and fibrous that it cannot be overcome by gradual dilatation.

The procedure is advisable in non-dilatable strictures where there is an extensive connective tissue deposit; those strictures where there is a persistent tendency for rapid contraction following dilatation; those strictures which, when dilated, produce local disturbances in the form of excessive bleeding or active urethritis, or constitutional disturbances such as chills, fever, and more or less suppression of urine.

The operations employed are:

1. Internal Urethrotomy (for strictures of the anterior urethra).
2. External Urethrotomy (for strictures of the posterior urethra).
3. Resection of the Stricture.

1. *Internal Urethrotomy.*—This operation is applicable only to strictures in front of the perineal urethra, which, in the average adult is less than five inches from the meatus. The mortality in a series of 4686 cases collected by Watson and Cunningham was 1.1 per cent.

Technic of Internal Urethrotomy.—Preparation.—When possible the urine should be made acid and aseptic before the operation is undertaken by the administration of proper drugs, large ingestions of water, and irrigations. Immediately prior to the operation the urethra should be thoroughly irrigated with permanganate of potash 1 to 4000, and it is desirable, if possible, to partially distend the bladder with this solution just before the operation is undertaken, so that this fluid, rather than urine, which may be septic, will be passed over the cut surfaces, if no retention catheter is employed. This may usually be done, even if a general anesthetic is not used, by means of a catheter, or forcing the fluid into the bladder by means of a syringe held tightly at the meatus.

Operation.—The operation usually requires a general anesthetic, but may, in some instances, be performed under local anesthesia alone, or combined with scopolamine and morphia, if the stricture is not extensive.

If the meatus is small, a meatotomy should always be done.

There are two methods of doing an internal urethrotomy, dependent upon the caliber of the stricture. If the stricture is of sufficient caliber to admit the Otis urethrotome, the strictured area may be divided by this instrument; but, if the stricture is too small to admit the Otis urethrotome, the stricture must be divided by the Maisonneuve urethrotome, with or without a filiform guide.

Internal Urethrotomy with the Otis Urethrotome.—The object of this operation is the division of the stricture by a longitudinal incision in the middle of the roof of the urethra by making the strictured area tense by the separation of the blades of the urethrotome, by the mechanism at the end of the shaft.

The stricture having been previously located, and its extent determined by bougie à boules, the Otis urethrotome is passed through it so that the end of the instrument projects but a short distance beyond

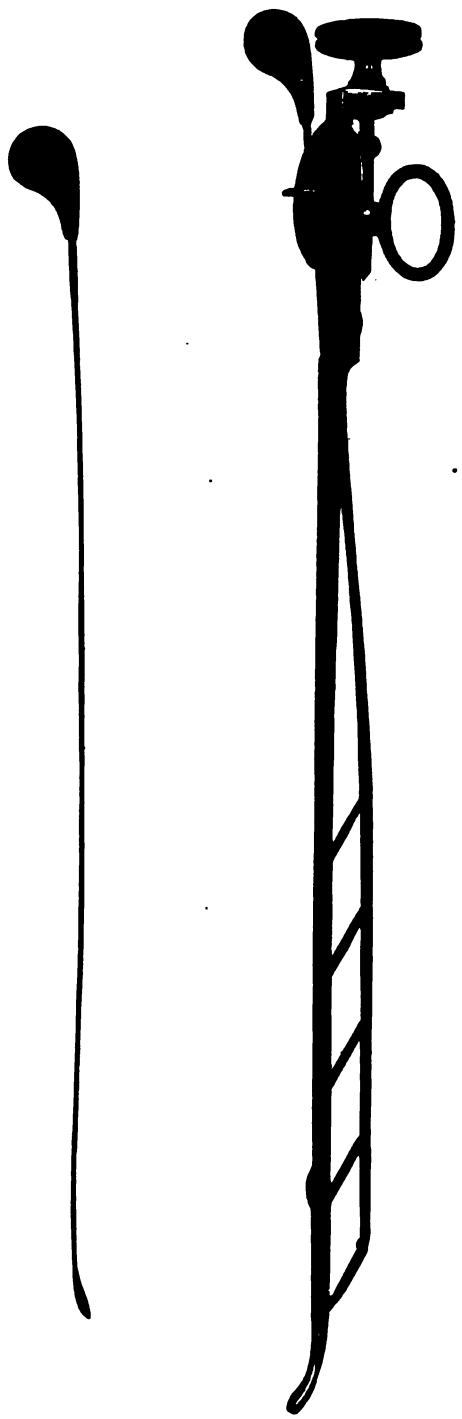

FIG. 230.—Otis urethrotome.

the deep end of the stricture, or engages it by the little shoulder on the Rand modification of this instrument. The blades of the instrument are then opened until moderate resistance is met. The concealed knife is then withdrawn through the strictured area so that the stricture is divided upon the middle and roof of the urethra. The knife having been returned, the blades then are more widely opened, and the

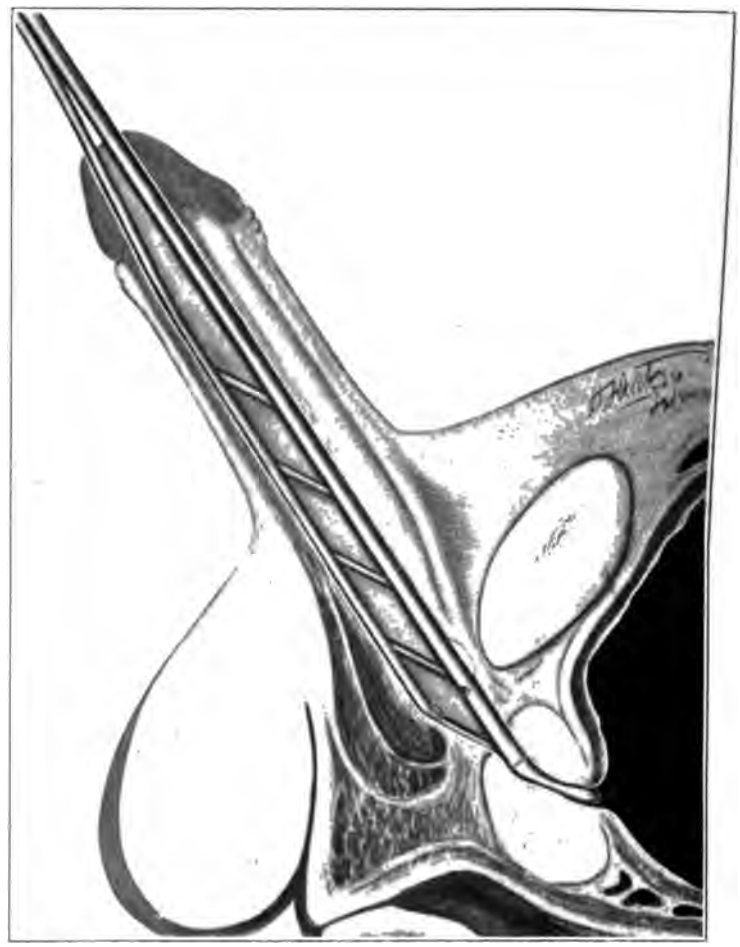

FIG. 231.—Otis urethrotome in position and blades open, putting the stricture on the stretch. (Watson and Cunningham.)

procedure repeated until the strictured area is divided to the full caliber of the urethra, or slightly beyond it. The knife being replaced in the shaft of the instrument, the blades are screwed together and the instrument carefully withdrawn.

The tendency for the blades to grasp the mucous membrane during their closure is overcome by slowly withdrawing the instrument while the blades are being brought together.

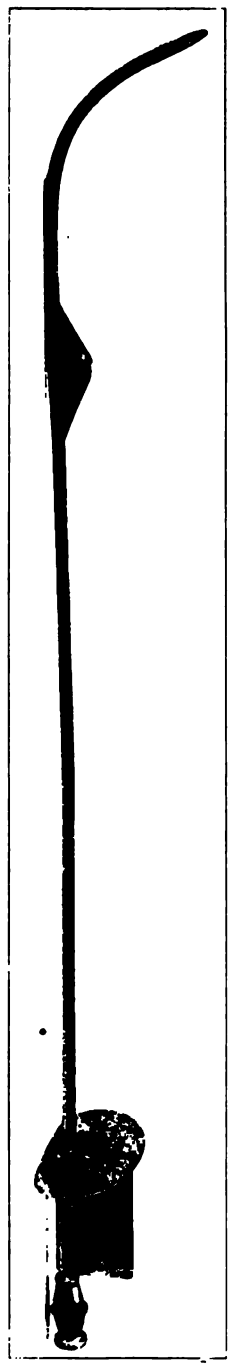

Fig. 232.—**Maisonneuve urethrotome.** (Cunningham modification.)

Following the removal of the urethrotome a bougie à boule, the largest which can be introduced at the meatus, should be passed and withdrawn to detect any undivided portion of the stricture, and if any exists, the urethrotome should be replaced and the undivided area cut. If none exists, sounds to the full size of the urethra should be passed through the divided stricture. The urethra should be thoroughly irrigated, and, unless the stricture has been one of small area, a catheter two sizes smaller than the size to which the urethra has been cut should

FIG. 233.—Showing the instrument in position being guided through the stricture by the filiform attachment coiled in the bladder, and the knife being forced onto the anterior face of the stricture. (The fingers of the left hand should be shown as grasping the head of the penis and holding it against the shelf at the handle of the instrument.) (Watson and Cunningham.)

be passed to the bladder, in order to keep the cut surfaces apart and at full dilatation, and left in position for three or four days, unless a urethritis develops; in which event it should be immediately removed. If, on the other hand, the strictured area is small, no catheter is necessary.

Internal Urethrotomy with a Maisonneuve Urethrotome.—The instrument should not have a groove which extends into the curve of the instrument. The modification made by Cunningham diminishes the possibility of the surgeon cutting his fingers; renders the operation safer

inasmuch as the knife will not be passed into the deep urethra, and facilitates the technic of the operation as the penis and instrument may be held by one hand while the stricture is cut by the other.

If the stricture is not smaller than 7 F., which is the caliber of the instrument, it may be passed through the strictured area, following which the knife is placed in the groove of the instrument and forced through the stricture, dividing it in the middle of the roof. The knife being made with a rounded shoulder at its summit prevents any but the strictured area from being divided.

If the stricture is of smaller caliber than 7 F., a filiform, which screws on to the end of the urethrotome, must be passed. The instrument then being screwed to the filiform is guided through the strictured area, and the stricture divided as just mentioned.

Following the division of a stricture by the Maisonneuve urethrotome there will remain, in most instances, a certain portion of the stricture which has not been divided. For that reason the Otis urethrotome is always employed to put the strictured area on the stretch, and the remaining portion of the stricture divided until the full caliber of the urethra is established. The urethra is then explored with a bougie à boule to determine that the stricture is entirely divided as previously mentioned, and the same indications for the presence or absence of a catheter in the urethra, following this operation, remain as stated when the Otis urethrotome alone is employed.

After-treatment.—Following the irrigation of the urethra and the passage of the catheter into the bladder and securing it there, the bladder should be thoroughly irrigated to insure the patency of the catheter, which may become plugged by blood clot. This irrigation should be continued until a free flow is assured.

The patient should receive hexamethylenamine, at least ten grains, four times a day, fluid should be forced, and the catheter allowed to remain in the urethra for three or four days, unless a urethritis develops, in which event it should be immediately removed and the urethra irrigated at least three times a day, preferably with permanganate of potash, 1 to 4000 or a solution of whatever drug is best adapted to the particular infection present in the bladder. If the bladder reaction remains alkaline a suspension of the Bacillus bulgaricus tablets should be used daily. If no catheter has been placed in the urethra, the urethra should be irrigated as just mentioned until all evidence of urethritis has disappeared, which will be within a few days to a few weeks.

Sounds, to the full caliber to which the urethra has been cut, must be passed every second or third day succeeding the operation, for at least two weeks, to insure the healing of the stricture at its full caliber. If a retention catheter has been employed, the interval of the passage of sounds should date from the day of its removal.

The urethra must be thoroughly irrigated prior and subsequent to the passage of instruments, as the unhealed surface favors the absorption of infected urine, which may result in chills, fever, and other general constitutional disturbances.

Dangers of Internal Urethrotomy.—The dangers of internal urethrotomy are (1) hemorrhage, (2) infiltration of urine, and (3) urinary fever.

1. *Hemorrhage.*—Moderate hemorrhage at the meatus usually follows the operation provided constant drainage has not been established by a catheter. The real danger from hemorrhage takes place by the blood passing backward into the bladder, and this is more liable to occur when the stricture is in the deeper portion of the anterior urethra.

The simplest method of arresting bleeding of this character is to pass a full size soft rubber catheter into the bladder, and establish constant drainage. Pressure on the penis, with a catheter in the urethra, by means of compressing the cut area either by sand bags or a firmly placed T-bandage, usually suffices. If hemorrhage is not controlled in this manner, an external urethrotomy should be done, a catheter placed into the bladder, *à demeure*, and the soft tissues packed firmly with gauze through the perineal incision.

2. *Infiltration of Urine.*—Infiltration of urine following internal urethrotomy is rare, yet does occur, and produces swelling of the penis, which may extend to the scrotum. The condition requires hot fomentations and, when severe, multiple incision. The condition should not be allowed to progress to the point of gangrene before liberal drainage is provided.

3. *Constitutional Disturbances.*—These may usually be avoided by keeping the urine acid and taking every precaution to cleanse the urethra prior to and following instrumentation, and by the administration of urinary antiseptics throughout the convalescence. The condition is more likely to occur if impairment of the kidney function exists prior to operation, which condition is not infrequently associated with stricture of long standing. Every attention should be given to stimulating the kidney secretion by the administration of caffein sodium benzoate, gr. ii every three hours, possibly digitalis, forcing of fluids, proctoclysis, subpectoral infusion, keeping the bowels active, and possibly hot packs.

2. *External Urethrotomy or Perineal Section.*—This operation is indicated when the stricture is located at a distance of more than five inches from the meatus, in other words, in the bulbous and membranous urethra. It is an operation of simplicity provided it is performed with a guide, which implies some instrument being passed through the stricture to the bladder. Without a guide the operation is one often attended with great difficulties, and every attempt, prior to undertaking the operation, should be employed to pass at least a filiform through the stricture to the bladder. The mortality in 2200 cases collected by Watson and Cunningham is 9 per cent.

(*a*) *External Urethrotomy With a Guide.—Technic.*—After thorough irrigation of the urethra with potassium permanganate solution an attempt should be made to pass a grooved staff through the strictured area while the patient is in the horizontal position, as it is most

difficult to pass instruments into the bladder with the patient in the lithotomy position. If successful, the staff should be held by an assistant while the patient is being placed in position and the perineum prepared.

The assistant making the groove of the staff prominent in the perineum and the operator lifting the testicles with the palm of the left hand, and outlining the instrument with the thumb and forefinger behind the bulb of the urethra, and at the same time drawing upward the skin of the perineum, a curved knife is thrust through the median line of the perineum until it engages in the groove of the staff. The

FIG. 234.—Rand knife threaded on filiform guide.

knife is then forced along in the groove for a distance of at least a half an inch and drawn straight outward thus opening the perineal tissues and urethra in the median line and leaving an incision of about three-quarters of an inch. The index finger of the right hand is then introduced into the wound, and the finger tip into the groove of the staff. With the left hand the handle of the staff is taken from the assistant. The instrument is gradually withdrawn until the tip is detected by the finger introduced through the perineal wound. Without withdrawing the instrument further, the finger at the tip of the staff is placed on the roof of the urethra, and forced onward into the prostatic urethra, and into the bladder. If this can be accomplished, the operation is

FIG. 235.—Wheelhouse's grooved staff with a groove on the front and back of the instrument, the advantage being that the filiform is held in the front groove so that it may not be divided while opening the urethra upon the staff.

essentially finished, it only being necessary to pass instruments from the anterior urethra to detect any stricture anterior to the point of incision in the perineum. If such exist the Otis urethrotome should be passed from the meatus after doing a meatotomy, if necessary, and by opening the blades the concealed knife is made to divide any stricture anterior to the point of the perineal incision.

The bladder should be searched for stone, either by a bimanual examination with the finger of the right hand in the bladder and exerting pressure with the left hand over the pubis, or by an instrument.

Sounds, the full size of the urethra, should be passed, the urethra

FIG. 236.—Curved knife through perineum into groove of staff just behind the bulb of the urethra. Testicle held upward. Index finger and thumb should be shown outlining the bulb.

FIG. 237.—Shows finger passed through perineal wound at tip of grooved staff into prostatic urethra.

thoroughly irrigated, a soft rubber catheter, two sizes smaller than the caliber of the urethra, placed from the meatus to the bladder, preferably a self-retaining DePezzer catheter.

If the arteries to the bulb have been divided, bleeding will be sharp, which requires that they be caught and tied. If there remains any oozing, which is most commonly the result of injury to the bulb, it may be controlled by firm packing, preferably with iodoform gauze strips, or suture.

If a grooved staff cannot be introduced as a guide, every attempt should be made to get at least a filiform through the strictured area, to which a special grooved staff may be attached after the manner of the Maisonneuve urethrotome, or a tunnelled sound may be passed over the filiform, and the operation performed as just outlined.

If only a filiform can be passed through the stricture, the perineal incision must be liberal and made cautiously, the edges of the wound retracted, the urethra identified and opened, so that the filiform may be seen. With the filiform as a guide the urethra may be incised by the knife along its course toward the bladder until the stricture is divided, or a Rand knife, which is a fine-bladed knife with a small loop on the end of the blade, may be inserted over the filiform; it having been drawn downward from the anterior urethra so that it presents in the perineal wound, and with the filiform in the loop of the knife the stricture is divided by forcing it along the course of the filiform.

Following the division of the perineal stricture the anterior urethra should be investigated and, if associated anterior stricture exists, should be divided as described under Internal Urethrotomy.

External Urethrotomy Without a Guide.—The Wheelhouse staff is passed into the urethra until it is arrested by the anterior face of the stricture, and held by an assistant. The instrument is made prominent in the perineum and a liberal incision is made in the groove of the staff so as to expose its end. The opened urethra is retracted by hooks or stay sutures, and held open while the knob at the end of the staff is made to engage the anterior end of the incision. A search is made for the opening of the canal through the stricture by means of filiforms or a fine probe. If the opening is found a filiform or probe is slipped along into the bladder and the stricture cut either by a scalpel or the Rand knife as previously mentioned.

The chief difficulty is in locating the opening through the stricture, and it may be necessary to dissect the strictured urethra from the surrounding tissue so that it is clearly outlined. Pressure over the bladder may force urine from the opening in the stricture and serve as a guide for this location. Another means of aid in finding the opening is to inject an aqueous solution of methylene blue into the urethra, and milking it backward by pressure on the perineal urethra prior to operation; and then washing the anterior urethra as free from the dye as possible, so as not to stain the surrounding tissues when the urethra is opened. In this manner the opening on the face of the stricture may be detected as a blue spot and serve as a means of detecting the urethral

canal in the strictured area. This procedure is also of aid while incising the strictured portion of the urethra in its longitudinal course Another procedure which may be resorted to is the division, transversely, of the strictured area of the urethra whereby the stained urethra becomes evident on cross section.

FIG. 238—The perineal urethra opened on a Wheelhouse Staff. The edges of the incised urethra held open by stay sutures. (Watson and Cunningham).

The procedure usually employed by the writer when the urethra cannot be detected by probing, or pressure over the bladder with an escape of urine, or by the methylene blue injection, is to introduce the index finger of the left hand into the rectum, identifying the apex of the prostate and incising the strictured area in a line with the urethra until the distal end of the stricture is opened. In this manner it is usually possible to establish the continuity of the urethral canal without difficulty, but is only to be employed by those who are especially familiar with the anatomy of this region.

Retrograde Catheterization.—Failure to establish the continuity of the urethra by the methods enumerated may require a suprapubic cystotomy, and the introduction of a guide into the prostatic urethra from above. A guide thus introduced indicates the internal end of the stricture and permits of a division of the strictured area through the perineal incision, provided a fine probe or filiform cannot be passed from a strictured area from above, in which event the stricture may be divided by a Rand knife or by carrying the incision along the course of the guide.

After-Treatment.—Following an external urethrotomy with or without a guide, a soft rubber catheter two sizes smaller than the caliber to which the urethra has been cut, should be passed from the meatus to the bladder, preferably a DePezzer self-retaining catheter. Hemastasis should receive attention, as it is a real danger, either by snapping and tying bleeding vessels, or firmly packing the wound with iodoform gauze; which packing may be started on the second day and removed on the third day as a rule. The urine should be rendered acid and the bladder irrigated at least three times daily with potassium permanganate, or some appropriate antiseptic fluid, and the patient's bowels prevented from moving for from three to five days for fear of soiling the wound, by the administration of pill opii, gr. j, twice a day, and when the bowels are to be moved an oil enema should be given as well as a cathartic.

The catheter should be left in position until the perineal wound is healed or a urethritis develops, the latter being the commonest indication for its removal, and may be expected to occur within a week. The first indications of its presence, either by a discharge from the meatus or at the perineal wound, should indicate its immediate removal.

The healing of the perineal wound is greatly facilitated by the employing of the *catheter à demeure* and the writer never employs a catheter through the perineal wound, as it is felt that the wounds heal much slower in consequence of such drainage. As a rule, the wound is closed, so far as leakage of urine is concerned within fourteen days, and it is not uncommon to have the urethra closed to the passage of urine within a week.

Following the removal of the catheter, sounds should be passed every second or third day until the perineal wound is healed, and the urethra should be dilated once a week for a month, once a fortnight for two months, and then once a month for three months following the operation. After this interval of time the patient should have a sound passed at least once a year, or at the interval found necessary to keep the urethra at full caliber.

Combined Internal and External Urethrotomy.—The necessity for a combination of these two operative procedures is not uncommon as associated anterior and posterior stricture often exists. The operation should be carried out as indicated under the separate headings, and requires nothing in the after care which is not common to both.

FIG. 239.[1]—Median perineal approach. Stricture and urethra in front and behind stricture opened.

FIG. 240.[1]—Dilatation of the urethra posterior to a stricture at the bulb.

FIG. 241[1].—Suture being placed to close anterior aspect of the divided urethra.

FIG. 242.[1]—Posterior surface of divided urethra united.

[1] Tr. Am. Assn. Genito-Urinary Surg., 1909, iv.

RESECTION.—This operation, although ancient in its conception and practice, has not received serious consideration by modern surgeons until recent years. For this reason the amount of material available for study is small as compared with that of other methods, and the claims made by those who advocate this operative procedure, while encouraging, must be open to further observation and study before the operation can be considered as the operation of choice in preference to external urethrotomy in the average case.

FIG. 243.[1]—Urethra united; bulb and soft tissues over it closed and catheter in the bladder.

The writer has, however, from his experience with this method of dealing with strictures of the urethra, a belief that resection of the urethra is especially indicated in strictures, usually of traumatic origin, which present an extensive amount of scar tissue about the urethra, which strictures, when treated by external urethrotomy, leave this excessive amount of scar tissue with the usual result of early recontraction of the urethral canal. The operation is also indicated for those strictures which recontract very rapidly after an external urethrotomy for the reason just mentioned, and which cannot be kept open by dilatation. It is not an operation attended by a high mortality. One hundred and fifty cases collected by Watson and Cunningham showed a mortality of but 2 per cent.

Operation.—The object of the operation is to remove all scar tissue, not only of the urethra, but the scar tissue surrounding it, which has an influence on the constriction of the urethra, and leaving the repaired urethral canal surrounded by normal soft tissue.

[1] Tr. Am. Assn. Genito-Urinary Surg., 1909, iv.

There are three methods employed in performing the operation:

1. Complete division of the urethra just in front of, and just behind the stricture. Removing the strictured part of the canal together with the scar tissue surrounding it, and to allow the interval thus made in the urethra to be reformed about a catheter passed from the meatus to the bladder, retaining it there until the healing is well advanced.

2. The same operation except that the divided ends of the urethra are united by suture.

3. Leaving the roof of the urethra instead of completely dividing the urethra and allowing the resected portion of the urethra to be reëstablished over a catheter passed from the meatus to the bladder as in the first procedure.

While the first and third methods are the simplest to employ, the second, uniting the severed ends of the urethra, is the one of choice, provided the technical difficulties encountered are not such as to make it impossible.

If the procedure is to be successful, certain features in the technic must be observed. In the first place the urethra must be sufficiently exposed and mobilized to permit of careful manipulations, and the placing of the sutures without tension. If the urethra is not sufficiently free, and the sutures are placed with tension they will pull out, causing urinary infiltration of the wound, with resulting sepsis, and the object of preventing further scar formation in the periurethral tissues will thus be defeated.

Technic.—The exposure of the strictured area may be accomplished by two methods:

1. By the patient in the exaggerated lithotomy position; exposing the deep urethra by a "V" shaped incision, with, or without a division of the median perineal tendon according to the location of the stricture and the necessity for exposure and satisfactory mobilization of the urethra; after the method of exposing the prostate and seminal vesicles as illustrated under Seminal Vesiculotomy.

2. A liberal median perineal incision as for external urethrotomy, dividing the structures of the bulb in the median line and retracting them, provided the stricture is located in the bulbous urethra, or dissection of the soft parts behind the bulb exposing the urethra at this point, provided the stricture is there located. Sufficient exposure should be made to thoroughly expose and mobilize the urethra beyond the stricture, so that when it has been resected that the ends may be brought together and the sutures passed without tension.

The stricture is then divided along its longitudinal axis upon a guide, if it can be passed through the stricture. If no guide can be passed through the stricture, a staff should be introduced through the urethra from the meatus to the anterior face of the stricture, and the urethra opened upon it in front of the stricture, or transversely, or the urethra opened on the staff by a short incision in the line of the urethra before the transverse incision is made in front of the stricture. The strictured area is grasped by forceps and dissected backward until the urethra at

the posterior face of the stricture is reached, when the urethra may be incised transversely just posterior to the strictured area, with or without a short longitudinal incision according to the caliber of the urethra in the individual case. The periurethral scar tissue may be removed with the stricture in some instances, but if not, it is to be cut away piece meal, if necessary. The severed ends of the urethra must be freely mobilized by blunt dissection, or by cutting if necessary, so as to allow the severed ends of the urethra to be brought together without tension. The sutures, preferably of No. 0 plain catgut, threaded on a fine curved needle, are placed so as to bring the divided ends of the urethra together in a transverse line of suture similar to that employed in a Heinecke-Mikulicz pyloroplasty. The last sutures are best placed following the passage of a large sound from the meatus to the bladder to act as a bobbin during the passage of all but the posterior suture and to insure the full circumference of the canal.

Following the completion of the union the urethra should be opened on the sound sufficiently to admit the passage of a No. 10 DePezzer catheter, the opening being as far posterior from the line of sutures as possible. A catheter, preferably a No. 10 F. DePezzer, is passed into the bladder through this urethral opening so that its head is properly located just beyond the vesical sphincter. If the "V" shaped incision is made, the repair should be made by replacing and suturing the perineal tendon if divided, and the external wound loosely united by interrupted silkworm gut sutures. If the exposure has been made by a median perineal incision with division of the bulb, the bulb should be united by a few interrupted No. 0 catgut sutures and the external wound partially closed by loose interrupted silkworm gut sutures. Oozing may require packing of the wound, more active bleeding often requires ligation.

After-care.—It is desirous that the catheter be retained until the external wound is nearly healed, but if sepsis appears liberal drainage should be provided by removing the skin sutures at an early date.

The anterior urethra should be irrigated once or twice daily by a careful injection of permanganate of potash 1 to 4000, every care being taken to insure a liberal reflow of the irrigating fluid so that no tension will be placed on the sutures or produce leakage between them.

After the removal of the catheter the irrigation should be continued daily until the opening in the urethra has healed, and as a rule no catheter should be passed from the meatus to the bladder to hasten this feature. Instruments should not be passed through the repaired area for at least three weeks, when it should be attempted, and if there is any tendency toward recontracture, regular dilatation should be performed until this is no longer a feature, or it is proven that the operation is a failure in establishing the full caliber of the urethra at the strictured point, when regular dilatation becomes necessary.

During the period immediately following the operation the patient should receive urinary antiseptics and fluids should be forced, the idea

being to diminish every possibility of sepsis while the catheter is in t[illegible] bladder, or during the process of healing of the wound.

SUMMARY OF CHOICE OF TREATMENT FOR URETHRAL STRICTURE.—[illegible] Considering the most appropriate form of treatment from the stan[illegible] point of mortality, relief of symptoms, and permanency of resul[illegible] it is evident that no one form of treatment is applicable to all strictu[illegible]

Gradual dilatation is attended by an unknown mortality. Dea[illegible] occasionally occurs, however, after the passage of a sound for the dilat[illegible] tion of stricture. It is rare, usually dependent upon defective kidne[illegible] and death is usually due to a suppression of urine.

Whether the relief of symptoms by gradual dilatation can be attain[illegible] may only be determined by making the attempt to treat the strict[illegible] by this method; and it is fair to say that anything but filiform strictu[illegible] may be symptomatically improved but not cured by regular dilatat[illegible] at stated intervals. Strictures anterior to the peno-scrotal angle c[illegible] tract less than strictures posterior to this point, and are more amena[illegible] to dilatation than posterior strictures. Strictures of gonorrheal ori[illegible] are less dense and progressive than traumatic strictures, and are m[illegible] suitable to treatment by dilatation.

As regards the results of treatment of strictures by dilatation, whe[illegible] ever located or whatever their origin, it may be safely stated tha[illegible] cure may never be expected; and while the full caliber of the uret[illegible] may be reëstablished in a fair percentage of cases, it will not rem[illegible] so, except rarely, and dilatation must be performed at stated interv[illegible] at which the stricture is found to give evidence of recontraction.

It is felt that gradual dilatation is the best method to employ, at first, with all strictures, at or less than five inches from the meat[illegible] which are suitable for its employment; by which is meant that th[illegible] can be dilated within a reasonable time; that they will maintain [illegible] dilatation for not less than a week after each sitting; and that [illegible] patient does not show constitutional disturbances of importance dur[illegible] the course of treatment. When all is said and done, gradual dilatat[illegible] must be considered a palliative rather than a curative method of treatment for urethral stricture regardless of its origin or location.

Internal Urethrotomy is attended by a mortality of about 1 per ce[illegible] It is the best treatment for any strictures other than those of la[illegible] caliber, which are seated within five inches from the meatus, for [illegible] reason that it is a safe method, increases the caliber of the strict[illegible] in the most rapid manner possible, and a permanency of results i[illegible] large proportion of cases is attained. It is *not* an operation wh[illegible] should be applied to strictures more deeply seated than a point f[illegible] inches from the meatus; because of the danger arising from sepsis a[illegible] hemorrhage. While a cure may be expected in a large proportion of cases, there is a small percentage which will require gradual dilatat[illegible] at stated intervals of time, subsequent to the operation, in order to keep the urethra at full caliber. Especially is this true in cases wh[illegible] the connective tissue deposit is extensive, and all strictures having b[illegible] divided by internal urethrotomy should be examined at intervals of

three months following the operation for at least one year, and should be further examined at yearly intervals for at least five years, before they may be considered as cured.

External Perineal Urethrotomy has a mortality of about 9 per cent. Included in this mortality are cases of rupture of the urethra from trauma, with or without fracture of the pelvis or multiple injuries, and extravasation of urine with general sepsis, which features add materially to the death rate. Operation as performed for uncomplicated stricture of the deep urethra has a mortality in the vicinity of 3 per cent. The cause of death, associated with this operation are sepsis, urinary suppression, and secondary hemorrhage.

External perineal urethrotomy is the most satisfactory form of treatment for cases of stricture of the deep urethra, which are not amenable to gradual dilatation, and which are not so dense as to demand resection. It is an operation frequently to be employed to control hemorrhage following internal urethrotomy, and to relieve the dangers of sepsis which may develop from this procedure. It is urged that it be employed early if hemorrhage or sepsis develops following internal urethrotomy, as this procedure is frequently delayed too long before being employed with these complications. External urethrotomy should always be immediately employed in cases of rupture of the urethra, as it controls hemorrhage, diminishes the chances of sepsis and urinary extravasation, and also lessens the amount of subsequent scar tissue which will be deposited in the urethral wall, and periurethral tissues. External urethrotomy is the only operation possible to employ in cases of impassable stricture of the deep urethra. It should always be attempted without a suprapubic opening or retrograde catheterization, which procedure, however, may necessarily have to be combined with external urethrotomy in certain cases of impassable stricture of the deep urethra.

Resection of the Urethra.—This procedure has a mortality of about 2 per cent. and should be chosen only in those cases of stricture in the region of the bulb or in the perineal urethra; which strictures are so dense and so surrounded by scar tissue in the periurethral tissues that they are not amenable to treatment by external urethrotomy alone.

Treatment for Complications of Stricture.—*Urinary Extravasation.*—The essential feature in the treatment of this complication is free drainage of the entire area involved; the evacuation of all pus areas, and removal of most, if not all, of the necrotic tissue. An external urethrotomy with division of the deep stricture should always be done at the time of draining the infiltrated tissues, if possible. Bladder drainage is essential and should be attained by passing a catheter from the external perineal incision into the bladder and not by the passage of a catheter *à demeure* for the reason that sepsis, which is present, will cause an active urethritis from the presence of a catheter in the anterior urethra. When the sepsis has subsided, a catheter from the meatus to the bladder may be employed, provided anterior strictures do not exist, and if they do they should be divided by internal urethrotomy.

The earlier extravasation of urine is provided with drainage the less suppuration, sloughing, and gangrene will result; furthermore, the constitutional symptoms dependent upon this condition, which are serious and frequently fatal, are averted or diminished, and recovery is more often to be expected.

Often the scrotum may be so gangrenous as to slough away entirely or nearly so, leaving the testicles exposed, but Nature, in a most surprising way, takes care of the situation in many instances; but if the testicles remain exposed when the tissue becomes healthy, their covering may be hastened by plastic operations suitable for the individual case. If strictures, the cause of the extravasation, are undivided at the primary operation, or again recontract, they should be dealt with after the tissues have become healthy.

Retention of Urine.—The treatment of retention of urine dependent upon urethral strictures is (1) palliative, (2) operative.

1. *Palliative Treatment.*—Hot sitz baths, belladonna and opium suppositories, together with hot fomentations over the bladder region may cause a partial, if not complete, emptying of the bladder and relief of the immediate distress.

2. *Operative Treatment.*—If palliative treatment is not successful, and no instrument can be passed into the bladder to relieve the retention, the bladder may be aspirated above the pubis by a trocar. The aspiration may result in allowing the bladder to partially empty itself following this procedure, but if not, it may be repeatedly aspirated; or by aspirating the bladder with a large cannula, a small soft rubber catheter (No. 8 F.) may be passed through the cannula and left in position following its removal.

Whenever possible an immediate operation for such retention should be performed, rather than to employ suprapubic aspiration, or resort to the permanent drainage instituted by a suprapubic catheter; for the reason that these measures are purely palliative, and the stricture will, in the near future, require division.

Urethral Fistula.—Urethral fistula, the result of stricture of the urethra, may occur at any point in the urethral canal, and is dependent upon sepsis behind the constricted area. It appears in the penial and perineal portion of the urethra as a periurethral abscess, and when such periurethral abscesses are left to rupture or are opened by incision, a urethral fistula may result and remains the point of least resistance for the escape of urine, which keeps the fistula open.

The first step in *treatment* is to divide the barrier in the urethral canal, which, when opened to the full caliber of the urethra and maintained so by gradual dilatation, may result in the healing of the fistula. On the other hand, if, after a sufficient period of time has elapsed to make this favorable outcome improbable, a plastic operation, as illustrated under Urinary Fistulæ in the consideration of the Complications of Acute Anterior Gonorrhea, may be employed; provided the fistula is in the pendulous portions of the urethra. If the fistula is in the perineum and associated with extensive scar tissue, the operation of

resection of the urethra is sometimes preferable to that of simple external urethrotomy provided that sepsis is no longer an associated feature.

False Passages.—A false passage in the urethra is usually made by forcing an instrument through the urethral wall during instrumentation, and less commonly is the result of periurethral abscesses, which rupture into the urethra.

The most common sites for false passages, the result of instrumentation, are at the bulbo-membranous junction, on the floor of the urethra; and on the roof of the urethra, just in front of the apex of the prostate, where the instrument may penetrate into the prevesical space. The immediate consequences of making false passages are hemorrhage, extravasation of urine, and periurethral abscess.

The *immediate treatment* to follow the realization of the making of a false passage is absolute rest, urinary antiseptics, to keep the urine free from infection, if possible, or if urinary infection already exists, immediate operation in the form of external urethrotomy with drainage of the bladder by introducing a catheter into it through the perineal wound, no matter where the rupture of the urethra has been made. It may occasionally be necessary, in order to control hemorrhage, to enlarge the opening made by the instrument through an external urethrotomy incision and packing the cavity. Suppuration, in some degree, will probably be present, following the removal of the packing and frequent irrigation may be necessary, together with every attempt to keep the urine as antiseptic as possible.

If the making of false passages is not immediately recognized, or if recognized and immediate operation not considered advisable, complete rest without further instrumentation, but with the ingestion of large amounts of water and urinary antiseptics, should immediately be instituted, and continued until some feature, dependent upon the injury, manifests itself, or the consequences of the error are proven to be negligible. Suspicion must be entertained that suppuration will probably develop at the point of injury, or hemorrhage may become pronounced and infiltrating, or that extravasation of urine into the surrounding tissues may take place. If any of these distressing features develop, they should receive appropriate treatment.

GONORRHEA AND ITS SURGICAL ASPECT IN THE MALE.

By JOHN H. CUNNINGHAM, M.D.

Gonorrhea is not only the most common venereal disease, but is the most common of all communicable diseases. Its complications in the male; phimosis, paraphimosis, periurethral abscess, Cowperitis, stricture, prostatic abscess, seminal vesiculitis, epididymitis, adenitis, sterility, and metastatic arthritis dependent upon this disease, often require surgical procedures.

Characteristics of the Gonococcus.—The gonococcus, the specific organism of gonorrhea, is a medium-size coffee-bean-shaped diplococcus, easily stained with the basic aniline dyes, Löffler's methylene blue being the one most generally used. It is decolorized by the Gram staining method, which differentiates it from other diplococci with which it may be confused. It has a peculiar affinity for mucous surfaces, is partially parasitic in character, produces active phagocytosis and is most commonly observed in smears, crowded in masses within pus cells, yet it may be found as an extracellular organism, especially when the lesion is of long standing.

The gonococcus dies quickly, except in living tissues, and is grown with difficulty on culture media, serum-agar, blood-agar, and sterile hydrocele fluid being the best. While the organism is peculiarly parasitic and dies with great rapidity out of the body, it is unquestionably that moist discharges, infecting clothing or other articles, are not infrequently the cause of spreading the disease, and accounts particularly for eye infections and epidemics among children in hospitals.

While the gonococcus is essentially an organism producing a local inflammation on mucous membranes, especially the urethra, rectum, mouth, eye and the female genitalia, it may produce a hemic infection, and in such instances it shows a peculiar selective action for serous surfaces, especially joints, tendon sheaths, the endocardium and the meninges. Some question exists as to whether or not this organism produces toxins, or antitoxic bodies, but it is absolutely proved that no immunity is established by the disease. It is also proved that the organism may lie dormant, and show little or no vitality after a long residence in an individual, but when such organisms are transmitted to other individuals, or the general or local resistance of the individual is lowered, their vitality is quickly reëstablished.

Complement-fixation Test.—The complement-fixation test as a diagnostic means in gonorrhea, commonly known as the Schwarz-McNeil test, is of value when a suspicion of the disease exists, and the gono-

coccus cannot be demonstrated. The test is specific for gonorrhea, has the peculiarity of being negative in the acute stage and positive in the chronic stage, with or without complications of the disease. A positive reaction indicates an active gonorrheal process somewhere in the body and an individual possessing a positive reaction must be considered infectious to others, even in the absence of clinical signs; the only exceptions being that a positive reaction usually persists for about two months in those clinically cured, and that such individuals may show a positive reaction after receiving gonorrheal vaccine. These facts should be borne in mind in giving a prognosis.

The special value of the test is in doubtful arthritic manifestations, pelvic conditions in the female, and in disease of the epididymis when the clinical history is questionable, and a differential diagnosis between tuberculosis and gonorrheal epididymitis is desired. It should always be borne in mind, however, that a patient may have more than one disease at the same time, and that while the complement-fixation test will give practically a 100 per cent. positive finding in gonorrheal arthritis and epididymitis, the clinical history, careful physical examination of the prostate and seminal vesicles, to locate the infection, laboratory tests, such as the Wassermann and tuberculin tests are not to be forgotten in the presence of a positive complement-fixation test for gonorrhea.

Mode of Infection and Pathologic Anatomy.—The urethral mucous membrane is rarely attacked by the gonococcus except by direct contact, in coitus, with material carrying this organism. The fossa navicularis, being covered with squamous epithelium, is most resistant to the gonococcus infection, and experimental evidence shows that when the epithelium in this region is normal that infection does not take place in this area, and that the organisms thrive only when they become implanted upon the columnar-epithelial lining of the pendulous portion of the urethra. Infection reaching this part of the urethra, produces in from two to fourteen days, and most commonly on the fifth day, an extensive infiltration of the epithelium and its basal membranes with leukocytes and round cells, and a purulent secretion exudes. This secretion, chiefly of pus and desquamated epithelium, abounds with intracellular and extracellular gonococci. The glands of Littré and crypts of Morgagni show early involvement and may carry the infection into the deeper urethral structures, even to the tissues of the corpus spongiosum; and thrombosis of some of the smaller bloodvessels in the erectal sinuses of this structure may take place, producing a symptomatic condition known as cordee. When the inflammation has become well established the glands of Littré and crypts of Morgagni become distended with the products of inflammation and the desquamation and destruction of superficial epithelial cells results in minute ulcerations.

While but portions of the anterior urethra may be the site of lesions it is more common that the entire anterior mucous membrane becomes involved in some degree at least, certain areas, however, exhibiting more pronounced activity than others.

The repair process depends chiefly upon the death of the organism, when there is a gradual desquamation of affected epithelial cells, absorption of the inflammatory exudate, and in the areas in which the infection has been most pronounced, a submucous infiltration by connective tissue may follow, narrowing the urethra at such points and producing the condition commonly known as stricture. The regeneration of the urethral epithelium rarely takes place completely and small areas of granulation tissue, especially at the mouths of the glands of Littré and crypts of Morgagni persist, and such remaining lesions are most commonly the cause of the shreds in the urine which may always be expected to persist following any inflammatory reaction of the urethra. The epithelial regeneration in the infected areas is not of the columnar variety, but is squamous in type.

The *posterior urethra* may become involved by an extension of the inflammatory reaction from the anterior urethra by continuity of the mucous membrane or possibly by the lymphatics. An infection of the deep urethra, protected naturally by the compressor-urethra or cut-off muscle, may be produced by spreading infectious material from the anterior urethra by irrigations or instrumentation, and these are probably the most common causes of the extension of the inflammation to this portion of the urethra.

Gonorrheal inflammation of the posterior urethra results, commonly, in an extension, by continuity, to Cowper's glands, the prostatic tissue, sinus pocularis, the ejaculatory ducts, and thence to the seminal vesicles, and down the vas deferens to the epididymis. The mucous membrane of the bladder being lined with a mucous membrane of the squamous type is most resistent, and is but rarely infected, and an extension to the kidneys *via* the ureters is a most unusual thing, and probably never occurs. A gonorrheal infection of these organs occasionally recorded in literature, should be considered hemic in origin.

When infection of the structures accessory to the deep urethra takes place, permanent damage results; the organism is most difficult to destroy, and relapses of symptoms may be expected at any time, and are especially prone to occur with the lowering of the individual's general resistance by an acute disease, such as pneumonia, influenza, etc., and by the lowering of the vitality of the parts by irritating elements in the urine, such as alcohol or even a concentrated urine.

Symptoms and Diagnosis.—The symptoms of gonorrheal urethritis differ according to whether or not the process is acute or chronic, and according to whether only the anterior or the posterior portions of the urethra are involved. Accordingly we have:

1. Acute Anterior Urethritis.
2. Acute Posterior Urethritis.
3. Chronic Anterior Urethritis.
4. Chronic Posterior Urethritis.

An acute posterior urethritis necessarily implies that an anterior inflammation co-exists, yet the symptoms are such that acute posterior urethritis should be considered as an entity.

ACUTE ANTERIOR URETHRITIS.

Symptoms.—The incubation period of the infection is most commonly four to six days, but the period cannot be considered to have passed before the fourteenth day; as the resistance of the individual and the virulence of the organism have an important influence upon the manifestations. During the incubation period there are no clinical signs except a slight burning or itching sensation, in some instances. The first symptom, if detected, is a thin mucous or muco-purulent discharge at the meatus, which within a few days becomes purulent in character, and in severe infections the discharge may become slightly bloody. The meatus usually becomes more or less reddened and occasionally the lips are edematous. Micturition is more or less painful, and if the process has invaded the erectile tissue of the corpus spongiosum, painful erections—commonly known as chordee, may be present, especially at night or when the bladder is full. As the acuteness of the process subsides, the discharge becomes less, muco-purulent in character, and the organisms gradually disappear.

The course of the disease, without complications, varies in length from one to six weeks under proper treatment, but shreds may be expected to remain in the urine indefinitely, and are permanent in about 80 per cent. of all cases.

Diagnosis.—The diagnosis is too often surmised and a microscopical diagnosis is most important and should not be neglected. It is becoming more generally realized that other organisms, especially the staphylococcus, streptococcus, and colon bacillus, often present in the vaginal discharge, may be implanted and produce an inflammatory reaction on the urethral mucous membrane, with all the attending symptoms of a gonorrheal infection. An active purulent discharge from the meatus does not always mean a gonorrhea, and the gonococcus must be found in the properly prepared microscopical slide to establish the diagnosis. As a rule, simple staining with Löffler's methyline-blue will demonstrate the gonococcus crowded within pus cells, but if the organisms are few and not typical in their arrangement a Gram stain, whereby the gonococcus is decolorized, should be employed. If the social features connected with the case are important, and the simple methyline-blue and Gram stains leave any doubt, a complement-fixation test and culture methods may be employed.

Considerable importance must be attached to establishing an acute urethritis as gonorrheal or otherwise, for a urethritis of non-gonorrheal origin is most persistent and chronic in its course, and it is only by a proper diagnosis that a proper prognosis can be made.

The *urine* should be passed in two glasses: "*The Two-glass Test.*" If the posterior urethra has not been involved, or at least enough to have the pus pass back and mix with the bladder urine, only the first urine will be cloudy with pus, epithelial cells, and mucous, the former settling to the bottom and the mucous floating as a light flocculent substance about it in the urine. A microscopical examination of the

sediment will show abundance of pus, cylindrical epithelial cells, many in clumps, mucus, and at a later stage some fibrin.

Treatment.—*Prophylaxis.*—The surest prophylaxis is the use of a condom throughout the act. The procedure which the writer has employed in his practice for many years and which is practically that adopted by the committee in charge of venereal diseases for the army, in the recent war, is as follows: Urinate immediately after coitus, wash the parts thoroughly with soap and water, and inject one dram of 10 per cent. argyrol, or a 1 per cent. protargol solution into the anterior urethra and hold it there for five minutes. The parts are then smeared with a 10 per cent. calomel ointment to prevent syphilis and chancroid. The parts are then wrapped with cotton-wool, and the ointment allowed to remain at least two hours before it is removed. Large amounts of water should be taken, at least one glass every two hours for three days, the idea being to frequently wash the urethra by urination. The beneficial results of such prophylaxis are difficult to estimate accurately for the obvious reason that one cannot say that coitus was with a gonorrheal subject, yet it is beyond question that it has great merit and is the most important feature in the program to prevent the spread of venereal disease.

The *treatment of the disease* varies according to the degree of inflammatory reaction present when the patient is first seen. The principle of the treatment, in whatever stage, has two important features: First, to keep the urethra free from the products of inflammation, and second, to apply antiseptics so frequently as to keep the urethra constantly bathed by them in order to destroy the organism. By large ingestions of water, at least one glass every hour, day and night, and frequent urination, at least once an hour, the pus and free organisms, which if allowed to remain in the urethra, may inoculate new areas, are washed away and the urethra kept as near clean as possible. Drugs taken internally are of little or no value, and would be so diluted as to have no therapeutic effect. By injecting an antiseptic after each urination, preferably freshly prepared argyrol in a 3 to 5 per cent. solution; or protargol in a .5 to 1 per cent. solution, according to the sensitiveness of the urethra, the organisms remaining after urination are rendered less active and finally killed.

The treatment should be employed at night as well as in the day for the obvious reason that the gonococcus knows no rest. This is the ideal application of the principles of treatment, subject, however, to circumstances. The most common modification is made necessary by the inability of the individual to take the injections regularly during the night, and in order to come as near as possible to the plan as outlined, one is instructed to drink a quart of water on retiring, which will require urination early during the night, when an injection may be made and more water taken, so that at least two urinations and injections are received. If during the day it is impossible to devote one's entire time to drinking, urinating, and injecting, one should urinate every hour, or as near to it as may be, and follow the urination by an

injection if possible. This form of treatment is applicable to infections of short duration, and to those without hyperacute inflammation.

The *hyperacute type* with profuse discharge, edema, intense inflammatory reactions of the organ, and pain during urination, require absolute rest, preferably in bed, and should not be treated as ambulatory patients. Soaking of the penis in warm water as much as possible, at least ten minutes every hour, hot fomentations between the soaks, a light semisolid or liquid diet are important. Alcohol, carbonated and alkaline waters and tonics are to be avoided as an acid urine is desirable; because an alkaline condition of the urine tends to promote bacterial growth. Sandalwood oil in 10-minim. capsules every four hours should

FIG. 244.—Operation for paraphimosis. Shows curved bistoury being inserted to one side of median line beneath constricting ring located near the corona. (Watson and Cunningham.)

be given to relieve painful urination unless it upsets the stomach; together with the ingestion of as much water as possible; this being governed by the degree of pain during micturition.

Local treatment, other than the soaks and fomentation, should not be started until the intense reaction has disappeared. At that time warm copious irrigations of potassium permanganate solutions, 1 to 5000 to 1 to 3000, once or twice daily, by means of a small catheter not over 10 F., and only introduced for two inches into the anterior urethra, and so placed as to insure a free reflow, are of benefit until the urethra becomes so free from sensitiveness that the injection method of treatment, already outlined, may be substituted.

Astringent injections are never to be used when the organisms are present, but are of value in the declining stage, used alternately with the antiseptic.

There is no one drug that holds a place, to the exclusion of others, in the treatment of gonorrhea. The silver protein compounds, argyrol, protargol, albargin, and many others, all being practically the same compound, form the best type of drug to employ as a gonococcocide. Acri-flavin, of which so much has been claimed by some, has not proved to be the specific, clinically, that it has scientifically, and in the writer's clinical experience with it over a period of five years, the conclusion is that it is just about as useful as the silver protein group, but no better.

FIG. 245.—Operation for paraphimosis, also showing director introduced beneath the constricting ring located high on penis. Division of ring to be done with a tenatome. (Watson and Cunningham.)

Surgical Complications of Acute Anterior Urethritis.

These are phimosis, paraphimosis, periurethral abscess, without or with a resulting urethral fistula, Cowperitis, stricture, and adenitis.

Phimosis and Paraphimosis.—Phimosis and paraphimosis often require a dorsal incision and this should be done without hesitation, as ulceration and destruction of tissues will take place, if a phimosis is such that it cannot be retracted, or a paraphimosis cannot be reduced.

Periurethral Abscesses.—Periurethral abscesses often subside with hot soaks, and when draining into the urethra should be opened from within the urethra, through an endoscope, but when large and not having ruptured into the urethra should be dealt with as any abscess, care being taken, however, not to incise the urethra, nor to destroy it by subsequently using carbolic acid in cleaning out the abscess cavity. The danger in opening periurethral abscesses is a resulting urinary sinus.

If a *urethral sinus* results, several months should be allowed to elapse, during which time the urethra should be treated with antiseptics and

FIG. 246

FIG. 247

FIG. 248

FIG. 246.—*Step 1. Lateral flap method.* Showing manner of excision of fistula and lateral flap outlined. Catheter in bladder. (Watson and Cunningham.)

FIG. 247.—*Step 2. Lateral flap method.* Showing the lateral flap freed and being brought into position over the fistula. Catheter in bladder and to remain there until the wound is healed. (Watson and Cunningham.)

FIG. 248.—*Step 1. Posterior and lateral flap method.* The incision to remove the fistulous tract and lateral flaps outlined. Catheter in bladder. (Watson and Cunningham.)

kept at full caliber, before any operation to close it should be undertaken, and this should never be done in the presence of acute urethral inflammation. If a repair of the sinus is undertaken one of the flap methods should be employed, as failure may be expected by simply freeing the edges and suturing them together.

Inguinal Adenitis or Bubo.—Inguinal adenitis or bubo accompanying acute gonorrhea is usually associated with ulceration of the prepuce, glans penis, or adjacent tissues, and the bacteriology is usually a mixed infection. Operative treatment, in the form of free drainage for the ulcerated area, by a dorsal incision of the prepuce, if necessary, soaks and moist dressings suffices to prevent suppuration in many cases;

yet the inguinal nodes often become involved and suppurate; especially when the staphylococcus is present. When the Ducrey bacillus is an associated organism, ulceration from broken down inguinal nodes may result, and is often extensive.

Treatment.—With suppurative adenitis, treatment by "seaton" should be employed when the suppuration is not extensive, and the skin over the infected area is healthy. A seaton of silk, changed daily, at which time the abscess cavity is emptied by pressure, washed with a strong antiseptic solution, and later filling the cavity with iodoform emulsion, is a form of treatment too seldom employed. Free incision,

FIG. 249

FIG. 250

FIG. 251

FIG. 249.—*Step 2. Posterior and lateral flap method.* The posterior flaps turned back and the posterior flap outlined; catheter in bladder. (Watson and Cunningham.)

FIG. 250.—*Step 3. Posterior and lateral flap method,* the posterior flap with skin surface turned inward over the fistulous opening; catheter in bladder. (Watson and Cunningham.)

FIG. 251.—*Step 4. Posterior and lateral flap method.* The lateral flaps turned over the posterior flap so that the raw surfaces are in apposition. Sutures placed so as to close the posterior denuded area. Catheter in bladder, to be left until wound is healed. (Watson and Cunningham.)

cauterizing the abscess cavity with crude carbolic acid followed by alcohol is, on the whole, the best treatment if the suppuration is advanced. Inflamed nodes not entering into the suppuration should not be removed. When the Ducrey bacillus is present in inguinal suppuration, resulting ulceration is prone to occur, is often extensive, is most difficult to heal, and the writer has come, though failure with palliative measures, to deal with them early, in a radical way. Under general anesthesia the whole ulcerated area is swabbed with crude nitric acid, special care being taken to clean beneath all shelving edges; the idea being to kill every organism, upon the success of which depends

the result. After every bit of the ulcer has been covered by the nitric acid the acid covered surface is neutralized with sodium bicarbonate. The connective-tissue wall surrounding the ulcer is then cut away so that a fresh border of normal tissue is left. The area of ulceration is thus converted into an eschar with an edge of clean normal tissue. Healing is slow, but when the surface becomes fresh, the area may be skin grafted if necessary.

FIG. 252.—Abscess of Cowper's gland. Rupture into urethra and soft parts producing extravasation of urine and death. (Watson and Cunningham.)

Cowperitis.—Cowper's glands, situated between the two layers of the triangular ligament, may become infected as the urethritis extends backward to the posterior urethra. It is usually unilateral, often escapes detection, unless suppuration occurs, and inflammation of these glands may be the cause of an unexplained urethral discharge. When the anterior urethra is not the site of lesions and the material expressed from the prostate and vesicles does not show products of inflammation, Cowper's glands infection is probable.

Symptoms and Diagnosis.—The symptoms vary according to whether or not the inflammatory process goes on to suppuration. If suppuration results, as it is prone to do, the subjective symptoms are pain of a throbbing character in the perineum, difficult and painful urination, and fever. Objectively there is an acute inflammatory swelling high

in the perineum, usually on one side of the median line. The whole perineum may become brawny and the inflammation with edema extended onto the scrotum. Fluctuation may or may not be present, and the condition is often mistaken for an ischiorectal abscess. Both urines are usually cloudy and contain pus, and the occurrence of such a condition in the perineum appearing in the course of a gonorrhea, and the presence of a pussy urine should establish the diagnosis.

If the infection does not proceed to suppuration; perineal pain of an indefinite character is the most prominent symptom, and upon examination the infected gland is detected as a small, hard swelling about the size of a pea, below and to one side of the apex of the prostate, by rectal palpation, and occasionally may be felt through the perineum.

Treatment.—At the onset of acute symptoms palliative treatment in the form of hot poultices, sitz baths, morphin, and sandalwood oil in large doses, forced fluids, and the omission of any urethral treatment may result in a resolution. As a rule, however, suppuration will result. If external local signs of suppuration become evident, early drainage is important, for it is desirable to drain the suppuration through the perineum before the abscess ruptures into the urethra, as a urinary sinus may then be avoided. If the abscess perforates the triangular ligament, as well as the urethra, as it sometimes does, infiltration of urine with gangrene of the perineum, scrotum, and penis will take place.

When a Cowperitis does not suppurate there is a small constant drainage of pus from it through its ducts into the urethra, and by employing the endoscope, granulation tissue or ulceration about the opening of its duct may be destroyed by cauterization and better drainage established. Pressure on the gland through the rectum or perineum, to empty it as much as possible, should be employed.

ACUTE POSTERIOR GONORRHEAL URETHRITIS.

This condition develops in about one-half of the cases of acute anterior urethritis. It occurs, as a rule, after the anterior urethritis has become subacute; yet may take place at any time while infection is still present in the anterior urethra. It is due most frequently to an extension, beyond the cut-off muscle, by the anterior infection travelling along the urethral mucous membrane; and while the posterior infection is often produced by too large an anterior injection or to instrumentation, it does occur spontaneously, which has given rise to the belief than an anterior gonorrheal urethritis may extend to the deep urethra by the lymphatics.

To guard against producing the condition during treatment it must be realized that the anterior urethra holds only a dram, patients must be impressed with this fact, and a syringe of suitable size should always be used by the patient. Irrigation of the anterior urethra by means of a catheter inserted into it must be most carefully carried out, not

introducing it more than two inches, and having little pressure to the flow, and a free return of the irrigating fluid; otherwise the cut-off muscle will relax, and infection may gain entrance to the posterior urethra.

The writer is convinced that the injection method of treatment of anterior urethritis is attended by a much smaller percentage of posterior involvement than by the irrigation method, and that the latter method of treatment should never be employed by the patient, and only by the physician in the hyperacute type of infection.

Symptoms and Diagnosis.—Clinically, posterior urethritis may be considered in two forms, *mild* and *severe*.

The onset of the *mild form* may cause no subjective symptoms, the only evidence of it being a cloudy second urine, which should always be differentiated from phosphates under such circumstances.

If the infection progresses and becomes at all *severe*, the prostrate becomes infected (acute prostatitis) and the inflammation may extend up the ejaculatory ducts to the seminal vesicles (acute seminal vesiculitis) and possibly down the vas deferens to the epididymis (acute epididymitis). The mucous membrane covering the bladder sphincter and the base of the bladder may become involved (acute trigonitis or cystitis). Frequent and painful urination occurs, often with most distressing tenesmus. Suprapubic and perineal pain are sometimes severe, and the patient usually has a temperature. Both the first and second urines contain abundant pus, and often blood. The prostate, and possibly the seminal vesicles, will be found enlarged and tender, and if the tenderness is not too severe, the fluid, which may be expressed from the prostate and vesicles, will appear more or less purulent and streaked with blood in the gross appearance, and microscopically will show pus, epithelial and blood cells, and gonococci. Retention of urine may occur from the acute inflammation in the prostate, and when requiring catheterization the urethra may have to be anesthetized.

Treatment.—In the *mild form* irrigations, once or twice a day, of argyrol 3 to 5 per cent., protargol .5 to 1 per cent., or if the process is very mild, or when it begins to subside, potassium permanganate about 1 to 3000 solution, or silver nitrate 1 to 5000 to 1 to 10,000 are to be used. The irrigation is best carried out by gravity or a large hand syringe, fitting the tip of either tightly at the meatus, and causing the fluid to traverse the anterior urethra, passing the cut-off muscle by overcoming it with pressure, through the prostatic urethra and into the bladder. When the bladder contains enough to cause the sensation to urinate, the patient should pass the fluid. The bladder should be so distended from two to four times, but the irrigation should be stopped if tenesmus develops during the procedure. The patient should be instructed to drink large amounts of water, sandalwood oil given to relieve painful urination, if a symptom, and hexamethylenamine as a urinary antiseptic.

After the process has become quiescent the prostate and seminal

vesicles should be massaged about every third day, as long as the products of inflammation remain in their secretions. Following the massage and irrigation, as just outlined, an instillation of argyrol 25 per cent., or some similar antiseptic into the deep urethra, should be made with a Keyes-Ultzmann syringe, after thoroughly cleaning the anterior urethra with potassium permanganate solution. This latter feature is necessary as some lesions will most probably still exist in the anterior urethra. Moreover, these lesions should receive attention as outlined under chronic anterior urethritis.

The *severe form* demands complete rest in bed and morphin and belladonna suppositories are usually required for the relief of pain, and to allay bladder tenesmus. The diet should be chiefly milk, water should be forced, and the bowels moved daily by a saline. Diuretics should not be given and the same applies to alkalies, in any form, as they favor the growth of bacteria in the bladder, and an acid reaction of the urine is desirable.

All local treatment in the form of injections or irrigations should be omitted. Hot sitz baths, and hot rectal irrigations, with a two-way flow, should be employed twice or more times daily; which helps to relieve pain and bladder tenesmus. Sandalwood oil in large doses, 10- to 15-minim. capsules every three hours, should be given, not only to relieve the distress in urination, but because of the curative effect. If the sandalwood upsets the stomach or causes backache, the dose should be diminished or the drug omitted.

The acute stage is usually of short duration, and may be expected to subside within a week; when the condition assumes the form of a mild posterior urethritis and then should be treated as such.

Surgical Complications of Acute Posterior Urethritis.

When acute infection is present in the deep urethra it may extend to the prostatic crypts, the sinus pocularis, through the ejaculatory ducts to the vesicles and down the vas deferens to the epididymis, possibly localizing as an abscess in the prostate, vesicles or epididymis.

Prostatic Abscess.—When the prostate becomes infected the suppurative processes are scattered through the gland as small focal abscesses, and if the suppuration progresses, these become confluent resulting in a larger pocket of pus. It may involve one or both lateral lobes.

Symptoms and Diagnosis.—The *symptoms* of prostatic abscess are constitutional and local. The constitutional symptoms are high fever, usually associated with chills and a marked prostration. The local symptoms are difficult and painful urination, often associated with retention of urine and rectal pain is usually severe. The *diagnosis* depends upon a previous history of a gonorrheal infection, and a urethral discharge, the high fever, chills, difficulty in urination, rectal pain, and a cloudy second urine. Objectively the presence of a purulent discharge at the meatus and an enlarged, extremely tender prostate

by rectal examination, sometimes with, and often without, fluctuation, unless the condition is of more than a few days' duration.

Treatment.—This may be *palliative* or *operative*. *Palliative.*—Local treatment in the form of injections or irrigations should be omitted. Hot sitz baths, heat to the perineum, either by poultices or a hot water bottle, as near constantly as possible, hot rectal irrigations with a two-way flow, at least twice a day, a light diet and a daily saline to move the bowels should be employed, if it is felt that an abscess has not definitely formed. Morphin and belladonna suppositories should be used as often as required to relieve pain, large amounts of water taken, and sandalwood oil should be given in large doses, if it produces no gastric upset. If retention of urine occurs, the patient must be catheterized with the smallest catheter possible, and only after washing the anterior urethra as clean as possible with some antiseptic. If the constitutional and local symptoms do not subside after a few days of such treatment, or if the symptoms and findings progress, also if retention of urine is a constant factor, operation is imperative.

Operative Treatment.—The procedure of puncturing a prostatic abscess through the rectum should be considered obsolete. The operation to be employed is either a median perineal section, or external urethrotomy, or an exposure of the prostate by a dissecting perineal operation, after the usual manner of exposing the prostate through the perineum.

If the prostatic abscess has ruptured into the urethra, but is not drained sufficiently to overcome the constitutional and local symptoms, the operation to be chosen should be an external urethrotomy and introduction of the finger into the prostatic urethra, breaking through the lateral walls of the prostatic urethra into the abscess cavity, thus evacuating the pus. If, on the other hand, the abscess has not broken into the urethra, it is best to approach it through the perineum, after the manner of exposing the prostate and seminal vesicles, as illustrated under Vesiculectomy. When the prostate is so exposed the prostatic capsule should be freely incised over each lateral lobe, the pus evacuated and the wound irrigated. The remaining prostatic tissue should be broken up by the finger, to open any small abscesses which may not have entered into the larger abscess cavity. Drainage tubes of small size, surrounded by iodoform gauze, should be placed in the abscess cavities, the median perineal tendon replaced and sutured, the external wound closed by interrupted sutures so as to allow the drainage tubes to protrude from either angle of the wound.

By whichever method the abscess is attacked, it is well to always open both lateral lobes, even though one is more evidently the site of abscess formation than the other, for the reason that the pathological process within the gland structure is primarily one of multiple minute abscess formation, some of which, by becoming confluent, form the abscess which may be evacuated; yet after so doing there will probably remain many small abscesses in the remaining prostatic tissue and to open one lobe of the gland without opening the other will most

probably result in the necessity of a second operation to evacuate pus from the other side in many instances. For the same reason it is necessary to break up all the prostatic tissue possible, at the same time that the pus cavity is opened, for if any focci are left, which do not drain, the usual train of symptoms indicating a chronic prostatitis will result. It has even been urged that at the time of opening the abscess that the remainder of the prostatic tissue, which may be expected to be infected, should be removed, and in any but young patients this is justifiable.

There is no question that patients, in whom all the prostatic tissue has been destroyed by abscess formations, have a prompter recovery, without the subsequent urethral discharge, which may be expected to remain from the infected prostatic tissue which is left.

The treatment, subsequent to the operation, should be directed toward overcoming the cystitis which usually persists, and treatment of the remaining chronic prostatitis, resulting from any remaining infected prostatic tissues as outlined under "Chronic Prostatitis."

Instruction should always be given to patients, after such an operation, to have the urethra examined for stricture at periods of at least one year apart for three years, for stricture in the deep urethra may result, and especially is this true if the abscess has been opened through an external urethrotomy incision.

Acute Seminal Vesiculitis.—The seminal vesicles are usually infected in some degree at least, whenever the prostate is actively inflamed; and whlle it is unusual, for some unknown reason, that the inflammatory process extends up both ejaculatory ducts simultaneously, it is not unusual for one to be infected following the other, and abscess formation in one or both vesicles is far more common than generally recognized. Acute suppurative seminal vesiculitis, usually associated with a severe infection in the prostate, with or without abscess formation, is usually overlooked and attributed to the prostate alone. The writer has observed a group of patients in whom there has been an abscess in the prostate, seminal vesicle, and in the epididymis, all true abscesses from which pus has been evacuated. There have been others in which the prostatic inflammation has not progressed to abscess formation, there existing, however, a true abscess in one vesicle. For this reason acute suppurative vesiculitis must always be thought of and investigated whenever prostatic suppuration, with or without accompanying epididymitis, exists.

Symptoms and Diagnosis.—The same subjective symptoms, both constitutional and local, are present in acute seminal vesiculitis as in acute prostatitis. The objective findings, however, aside from an enlarged and tender prostate, are an enlarged and tender vesicle on one side or both sides, the condition usually being unilaterl. An existing acute epididymitis on the side of the enlarged vesicle, if present, is an added factor in establishing the diagnosis.

Treatment.—The treatment of this condition is identical with that of prostatic abscess. The value of evacuating pus from the seminal vesicle has not been so generally recognized, however. If the process

is not becoming progressively worse, palliative treatment, as already outlined under prostatic abscess, may be prolonged with more reason, in most instances; yet even if palliative treatment results in the subsidence of the acute symptoms there will remain the usual trail of symptoms accompanying chronic prostatitis and vesiculitis, which must be treated over long periods of time and even then may not be cured.

Operative Treatment.—The writer is convinced that when suppuration exists in the seminal vesicles that operative treatment, which consists in exposing the seminal vesicles by a perineal dissecting operation, as illustrated, is a procedure which not only lessens the duration of the acute symptoms, in the same manner as does applying the ordinary principles of drainage to any suppurative process, but overcomes the necessity of prolonged treatment of the chronic inflammation which will result following the disappearance of the acute inflammation. It is always to be borne in mind in doing this operation upon the seminal vesicles, for the evacuation of pus, that the same condition of multiple abscess formation exists, as in the prostate, and that the vesicle must either be thoroughly opened by free incision and all parts of it thoroughly cleaned with carbolic acid and alcohol, or it should be removed as one would an appendix distended with pus. Moreover, it should be remembered that there is a coexisting inflammation in the prostate, and while the prostate may not be the site of true abscess formation, that multiple foci of infection exists there, and for this reason the prostatic capsule over both lateral lobes should be incised and the prostatic tissue freely opened and drained. It has been evident, in many cases, that acute suppurative vesiculitis occurs unilaterally; yet there exists, at the same time, some inflammation in the other vesicle, and for this reason it too should be incised, and if not found to be grossly the site of inflammation, free incision will suffice to drain it.

One of the arguments against this radical method of dealing with acute vesiculitis is that sterility may result. The operation should not be advised in patients with a mild vesiculitis, but rather to those where suppuration is evident. In these, and very likely also in those with a milder vesiculitis, sterility will result even without operation and, moreover, if the operation of draining the vesicles or removing them in their acute stage is performed, the patient is freed from the long period of treatment which will be necessary to eliminate infectious material and overcome symptoms. In fact, it is well recognized that the resulting chronic inflammatory condition of the vesicles, giving rise to a chronic urethral discharge, cannot always be cured by non-operative methods, and in some it is only by removing them that the patient is cured.

Acute Epididymitis.—This condition is the result of an invasion, by the gonococcus, passing from the posterior urethra to the epididymis by way of the seminal vesicles and vas deferens, and always has associated with it some degree of gonorrheal inflammation in the prostate and seminal vesicle on the affected side. The condition is

unilateral; simultaneous bilateral epididymitis being extremely rare. The subsidence of the process in one epididymis with its subsequent appearance in the organ of the opposite side in the course of a few days, is, however, occasionally observed. Why the inflammation extends along one ejaculatory duct, and not the other at the same time, as these two ducts open at a distance from each other of but a few millimeters, is not clear. Acute epididymitis should not be considered as an entity, but rather as one feature of an acute inflammatory process involving the posterior urethra, prostate, and seminal vesicle as well, with the most evident feature of the infection being localized in the epididymis. For this reason the treatment of acute epididymitis, either expectantly or by operation, is only one step in relieving the patient of the inflammatory process.

FIG. 253.—Method of supporting the testicles by a bridge of sheet tin. (Watson and Cunningham.)

The pathological process present in the epididymis is a number of foci of acute inflammation, which may result in suppuration. The infection starts in the tail, often extends to the body, and may be present in the head of the epididymis; but the testicle is rarely invaded. A secondary hydrocele dependent upon the inflammation in the epididymis is always present in some degree.

Symptoms and Diagnosis.—A history of a posterior gonorrheal urethritis is always present. The purulent discharge at the meatus generally ceases at the onset, and the patient first complains of backache and a pain along the inguinal canal several hours before any signs appear in the epididymis. When the process starts in the epididymis there is severe pain in the testicle radiating to the groin and back, and

the patient has a fever, often high. Objectively there will be found little discharge at the meatus, but both urines cloudy and containing pus. The scrotum on the affected side is more or less swollen, according to the amount of secondary hydrocele, which if small, will permit of palpation of the epididymis, which will be found enlarged and surrounding the testicle so that the testicle is not definitely outlined. The epididymis is extremely tender, and the spermatic cord more or less thickened and painful to pressure. The scrotal skin is often acutely reddened and more or less edematous. Rectal examination will usually reveal a distended painful vesicle on the affected side, which may also be true of the prostate.

Treatment.—This is both *palliative* and *operative*.. *Palliative treatment* consists in complete rest in bed, with testicles elevated, a light liquid diet, morphin to relieve pain, and a daily saline. All local treatment of the urethra should be omitted. Hot applications in the form of poultices, or an ice-bag, if the condition is not severe, should be employed, placing either of them beneath the scrotum on the scrotal support. The various medical applications to the scrotum are of questionable value. The prompt institution of treatment may result in a subsidence of the epididymitis in a few days, and when the temperature becomes normal and the pain absent, the patient may be allowed to get up with a well-fitting suspensory bandage. The secondary hydrocele usually absolves, but in some it will remain permanent. Treatment of the inflammation in the vesicle and prostate, posterior urethra, or even lesions in the anterior urethra should not be reëmployed for at least a week after the subsidence of all acute symptoms; because recurrent epididymitis is prone to occur.

Operative Treatment.—If the process in the epididymis is progressive under palliative treatment, the pain will become most severe, the temperature high and septic in character, and a constitutional prostration more or less pronounced. The secondary hydrocele will increase and the scrotal edema and inflammation progressively worse. Under these conditions palliative treatment will result in prolonged suffering of a severe character, the patient will have been confined to bed for from two to four weeks before the process subsides enough to allow him to leave his bed, and the weakness, incident to suffering, light diet and confinement, is to be avoided by applying the commonly employed surgical principles of drainage to an inflamed structure. By surgical intervention in these severe cases of epididymitis the patient is immediately relieved of pain, the temperature drops to normal within twenty-four hours, and the patient is confined to the hospital but four days, as a rule, and is able to be about attending to ordinary affairs within a week.

Technic of Operation.—Under a general anesthesia the scrotum is opened by an incision on its anterior aspect, and the hydrocele fluid allowed to escape. The swollen epididymis, with the testicle, is delivered and any adhesions between its outer aspect and the tunica vaginalis are destroyed by the finger. The epididymis is punctured

FIG. 254.—Testicle delivered and epididymis punctured on outer aspect.

FIG. 255.—Method of closing scrotal wound. This method is applicable to the closure of scrotal wounds following any scrotal operation. Note the stay sutures including all structures divided by the scrotal incision, and tied over rubber tubes; the external wound closed by a subcuticular silkworm-gut suture; the drainage tissue protruding from a stab wound in the bottom of the scrotum.

in many places over the most inflamed area, which is usually the tail. The punctures are best made with an eye knife and must penetrate the infiltrated fibrous covering of the epididymis so as to go deeply into the tissues. Serum or pus will escape. If the body and head of the epididymis show evidence of inflammation, as they usually do in some degree, they should be liberally punctured. The punctures should always be made on the outer aspect of the epididymis as the blood supply is more abundant on the inner side. After making the punctures the epididymis should be thoroughly squeezed, any abscess cavities dilated, and the entire cavity of the tunica vaginalis sponged out with mild corrosive sublimate solution, followed by sterile water. A stab wound is made in the bottom of the scrotum, through which is inserted a rubber dam or tissue drain, which should be placed along the entire course of the punctured epididymis. The wound in the scrotum is closed, preferably by two mattress sutures, including skin subcuticular tissue, the dartos, and tunica vaginalis, and tied over rubber tubes placed parallel to either side of the wound. By so closing the wound all the structures are brought in apposition without the use of catgut, which does not heal kindly in scrotal tissue, and the dartos which, being a muscle tissue, has a tendency to retract, is thus caught and held, preventing bleeding from its cut edge, so that scrotal ecchymosis or infiltration of the lax scrotal tissues, with blood, never occurs. The skin incision is closed by a subcuticular silkworm-gut suture, and an adhesive plaster scrotal suspension bandage is applied (Figs. 256 and 257).

The following day the mattress sutures and rubber tubes are removed. The tubes are best removed in less than twenty-four hours, preferably fifteen hours, because if left too long, gangrene of the tissue about the wound will result from lack of blood supply. The drainage tube is started on the second day and removed on the third day, and the wound subsequently dressed daily. The skin suture is removed on the seventh day. The patient should continue to wear a suspensory bandage for at least two weeks.

Treatment of the infection in the seminal vesicles and prostate may be begun, as a rule, within a week which is much sooner than may be done, with safety, if the patient is treated by palliation.

The examination of the secondary hydrocele fluid has failed to show organisms, but organisms, always the gonococcus, have usually been recovered from the pus and serum evacuated from the epididymis. Pus has been present, sometimes only a small drop, in about 70 per cent. of the cases. In the cases where pus formations had not taken place, the same result in alleviating suffering and shortening the duration of the disease has been quite as brilliant. A recurrent epididymitis on the side operated upon has occurred in but one patient. The lesions in the prostate and vesicle have been more amendable to treatment than when the epididymitis has been treated in a palliative way.

In the writer's series of over 300 operations, there have been 20

FIG. 256.—Adhesive plaster support; shows plaster placed across the perineum.

FIG. 257.—Shows support applied, holding the scrotum supported. The edges are adhered together to obtain lateral pressure. When the dressing is done, the strips are divided above the scrotum, replaced and held by safety pins. This dressing is worn until the wound is healed.

patients who have acquired an epididymitis on the other side, and who have been subjected to a bilateral operation. It is of interest to note that sterility is present in less than half of them, which is at least as good, if not a better outcome, than bilateral epididymitis treated by palliative methods. Following epididymitis, treated expectantly, sterility has been dependent most commonly upon the connective-tissue repair process in the tail of the epididymis, which is often evident as a persistent nodule, which obstructs the passage of semen from the testicle to the vas deferens.

Azoöspermia.—This condition is most commonly due to bilateral obstruction of the vas deferens, and is the result of gonorrheal epididymitis in about 90 per cent. of cases, the remaining 10 per cent. being due to syphilis and tuberculosis of the epididymis. Fruger, in a series of 242 patients, who had suffered double gonorrheal epididymitis, found 207 to be without spermatozoa.

The pathological process is an obstruction of the vas deferens, usually in the tail of the epididymis, due to scar tissue resulting from the connective-tissue repair process following gonorrheal epididymitis, which contracting presses upon the seminipherous testicles, obliterates the lumen of the vas deferens.

Treatment.—Anti-syphilitic treatment, when the lesion is due to syphilis, sometimes causes absorption of the infiltration and the patency of the vas is restored. Benefit, in a tuberculous obstruction must be considered impossible. If an obstruction is due to gonorrhea and the obstruction persists for three years, nothing in the way of treatment is of any value except to do an anastomosis of the vas deferens with a functionating portion of the epididymis or testicle at a point above the obstruction, which was suggested and first carried out by Dr. Edward Martin.

Operation.—The success of the operation depends upon a functionating testicle, patency of the vas deferens above the point of occlusion, and a perfect and patent anastomosis. The operation should be done under a general anesthesia and is usually carried out on both sides at one setting. The operation has been successful in the writer's hands in about 60 per cent. of the patients. It has always been undertaken with the understanding that failure may be expected, that no other course is of any value, and that everything may be gained and nothing lost.

Technic.—A small soft rubber catheter is placed in the bladder through the urethra and left there during the operation. The scrotum is opened, the testicle and epididymis delivered. The vas deferens and spermatic artery are identified by opening the sheath of the spermatic cord on the outer side. The vas deferens is freed and its lumen opened by a small incision in its long axis, just below the level of the globus major. A small syringe containing 3 per cent. argyrol is fitted into the incised vas deferens and about one dram of the argyrol is slowly forced upward toward the seminal vesicle. The argyrol will be shown to be present in the washings from the bladder or urethra, by

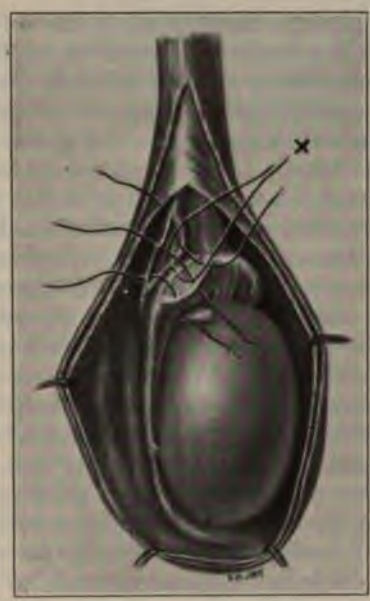

FIG. 258.—Method of placing sutures in anastomosis of the vas deferens and head of the epididymis. Suture marked x is the artist's error. This suture should be placed so that the knot is tied outside instead of inside. (Watson and Cunningham.)

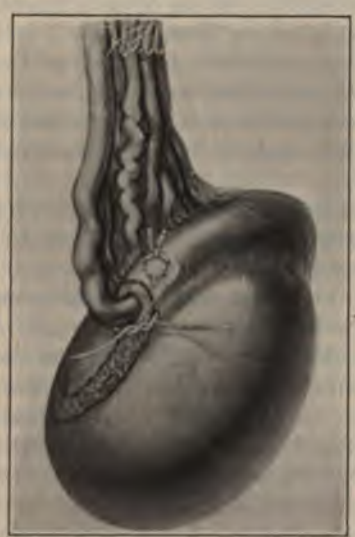

FIG. 259.—Anastomosis between the vas deferens and body of the epididymis after a partial epididymectomy. The cut end of the vas deferens is split and tunneled into the body of the epididymis. (Watson and Cunningham.)

FIG. 260.—Epididymectomy with anastomosis of the vas deferens with the rete testis. The union is made with Lembert sutures so that the line of union will be buried when the sutures are tied. (Watson and Cunningham.)

means of irrigating through the catheter, if the vas deferens or seminal vesicle is not occluded. If the dye cannot be made to appear by way of the urethra, the operation on that side will not be successful, and should be abandoned. If the dye appears by the urethra, the next step is to demonstrate spermatazoa in the globus major. A portion of it, free from bloodvessels, should be picked up with firm forceps and an elliptical piece about 1.5 to 2.5 cm. long, and .5 to 1 cm. wide should be removed by fine bladed eye scissors. The avoidance of opening any bloodvessels is essential. The fluid expressed should be collected on a cover-glass and immediately examined for spermatozoa, preferably on a warm stage microscope. If they are not present, another area may be tested, if the vascularity of the area will permit, and the fluid from it tested. Spermatozoa being demonstrated, or even in the event of not demonstrating them after the examination of all available areas, the opening in the vas deferens should be enlarged by extending the incision in it; so that it will be slightly longer than the opened area to be used in the globus major. Four fine, plain catgut sutures 00 or the finest silver wire, threaded on small thin curved needles, are placed, one at either end of the opening in the vas, one on either side of the opening in the vas, and the anastomosis made by placing the sutures through the tissues near the edges of the eliptical opening in the globus major so that the incision in the vas deferens will be opened and cover the opening in the globus major, and all knots tied from the outside. The greatest care must be taken not to injure minute bloodvessels as hemostasis is most essential to success, for the obvious reason that the minute openings are readily occluded by blood clot.

One side having been completed the procedure is repeated on the other organ, the only feature requiring attention being to free the urethra and bladder of the presence of argyrol to such a degree that it may be demonstrated that fresh argyrol is made to traverse the other canal.

The success of the operation must not be judged for six months, for in many instances spermatozoa failing to be found earlier after the operation have been demonstrated at later periods.

Modifications of this operation have been employed in connection with the removal of the obstructing portion of the epididymis (a partial epididymectomy), in which the vas deferens is divided and the end tunneled into the globus major, spermatozoa having been demonstrated in this area. Also when the whole epididymis has been removed (epididymectomy), as for tuberculosis, the vas deferens may be divided, and the end being cut as a whistle tip is sutured over a portion of the rete testis.

CHRONIC ANTERIOR URETHRITIS.

This condition should imply that there remains certain lesions in the anterior urethra following the subsidence of the acute inflammation, which manifest themselves by a small amount of purulent or muco-

purulent urethral discharge. These lesions are either areas of erosion of the mucous membrane, with or without urethral stricture, or remaining chronic inflammation in the glands of Littré or Morgagni crypt, and not infrequently all such lesions exist together.

Symptoms.—The symptoms of chronic anterior urethritis are the presence of a urethral discharge of muco-purulent or purulent character, persisting over a period of several weeks following the subsidence of acute manifestation. The subjective symptoms are of little moment, there being nothing that the patient complains of except a persisting discharge; or after all symptoms having once disappeared, again reappear with or without known cause. Objectively there may be a small indurated area somewhere in the course of the pendulous portion of the urethra, which may be detected by palpation. Such a lesion is an accumulation of the products of inflammation within the deeper anterior urethral structure, usually within and surrounding a gland of Littré, which lesion having been particularly active in the acute process has been partially walled off by a connective-tissue reaction.

Diagnosis.—The diagnosis depends upon a more or less cloudy first urine containing large shreds, which is evidence of the remaining lesions in the urethra. Often, however, the first urine may be clear or nearly so, but containing large cobwebby or long shreds, composed mostly of fibrin, desquamated epithelial cells, mucus and containing leukocytes and possibly organisms; the gonococcus or a variety of cocci, within their meshes. If no posterior involvement is associated with the chronic lesions in the anterior urethra, the second urine will be clear, and without shreds.

The diagnosis consists in making a smear from the discharge at the meatus, prior to passing the urine; determining, by the bougie á boule, whether or not there are narrowings or strictures in the urethra, due to a deposit of fibroid tissue about the persisting lesions, and an inspection of the canal by the anterior endoscope.

The *smear* will show a varying amount of pus, desquamated epithelium, of the columnar or squamous variety, mucus, fibrin, possibly the gonococcus and often other organisms, especially the staphylococcus and streptococcus.

The *urine* may vary between cloudy and clear, according to the activity of the process. There is nothing distinctive of chronic anterior urethritis except the shreds, which are of a cobwebby or fine slender shape.

The *examination with the bougie á boule* may detect narrowings in the urethra, the most common site being at the peno-scrotal angle. Early appreciation of beginning deep infiltration of the urethral canal, by recognizing a resistance to the withdrawing of the bougie á boule, permits of treatment and subsequent absorption of these diseased areas and lessens the chances of resulting stricture. It is essential at the time of such an examination to be sure that the meatus is not smaller than the caliber of the rest of the urethra, for a contracted meatus will impede the outflow of urine, which may be infected and is often the

cause of constantly irritating any lesions in the canal by back pressure during urination, and may even produce an erosion of the mucous membrane in the fossa navicularis. If the meatus is smaller in caliber than the rest of the canal, a meatotomy should be done, and only after this can the remainder of the urethra be properly examined by the bougie á boule or endoscope.

The *endoscopic examination* is the only means of recognizing lesions, other than stricture; determines their number, location and character, and its employment is often the only means by which proper treatment can be carried out.

Treatment.—Appropriate treatment will depend upon the character of the lesions present in the individual case. Briefly stated, the aim of treatment is to destroy the gonococcus if present, and to cure persisting inflammation resulting from the infection. To this end frequent urination, produced by large ingestions of water, at least twenty glasses a day, and a pint to a quart at retiring at night, so that during the day urination may take place every hour, and at least once during the night. This tends to keep the urethra free from the products of inflammation and wash away any free organisms, if present. If the urine is cloudy, or the gonococcus or other organisms are present, an injection of a dram of freshly prepared argyrol 3 to 5 per cent., protargol 0.5 to 1 per cent., according to the sensitiveness of the urethra, after each urinating, if possible, should be employed. If, however, the gonococcus or other organisms are absent, and the urine clear, or nearly so, such antigonococcic treatment is of less value, and in such a condition the cauterization of the isolated diseased areas by silver nitrate, 25 to 50 per cent., applied through the endoscope by means of swabs, or destroying the areas by a galvanocautery needle, or fulguration, is indicated at intervals of from five to eight days. Between such treatments the patient should use an astringent injection two to four times a day of a .5 to 1 per cent. zinc sulphate solution, or any of the recognized astringent injections prepared and sold in tablet form by leading chemists. The injection should never be of more than one dram, and should be held in the urethra for about two minutes.

If any deep infiltration or beginning stricture exists, occasional dilatation, about once a week, to the full size of the urethra, is most important to influence their absorption, and this may be carried out in connection with the other treatment as just outlined, if such lesions exist together. It is most important to always thoroughly cleanse the urethra before passing the sound or any instrument, for if the mucous membrane is injured and infectious material is present in the urethra at the time, a new area of infection may be produced.

If there has been any suggestion of deep infiltration, the patient should be instructed, at the cessation of treatment, to receive an examination for beginning stricture, once a year for three years. Neglect to do this too often results in stricture formation without symptoms, until it is well advanced.

It is necessary for the patient to continue to drink liberally of water,

to avoid irritating foods such as condiments, alcohol, carbonate waters, and acid foods for many weeks following the subsidence of all symptoms, quite as much as during the presence of symptoms, for the urethra still being in a relatively sensitive condition relapses are prone to occur and it should be given every chance to become as near normal as possible.

CHRONIC POSTERIOR URETHRITIS.

This condition should imply that chronic inflammatory changes exist in the mucous membrane of the posterior urethra, the sinus pocularis, the prostate and seminal vesicles. Lesions in all these strictures frequently exist together in some degree; are often more evident in one structure than the other, and the prostate is the commonest of all in harboring old infection and producing symptoms. Chronic inflammation often exists in both the anterior and posterior urethra at the same time, yet a persistent chronic urethral discharge originates far more commonly from lesions in the posterior urethra, particularly a chronic prostatitis, than from chronic lesions in the anterior urethra.

Etiology.—While the etiological factor producing a chronic posterior urethritis is almost invariably a previous acute posterior urethritis of gonorrheal origin, there seems to be other factors which must be sought for to explain a chronic posterior urethritis without a gonorrheal infection. This small group is supposed to be due to a prolonged and repeated congestion of the posterior urethra by constipation, excessive sexual intercourse, sexual abuses, ungratified sexual excitement, and perineal trauma, such as motorcycle and horseback riding. These factors producing a posterior urethritis may almost always be associated with sexual neurasthenia. The pathological changes observed in this group are chiefly a congestion of the posterior urethral mucous membrane and particularly of the colliculus seminalis or verumontanum, which is the most sensitive portion of the urethra, and sometimes known as the "sexual heart." This group is of surgical interest only from the necessity of differentiating them from a posterior urethritis of gonorrheal origin, and because of the necessity, in some instances, of surgically removing the diseased verumontanum in an attempt to cure the train of neurasthenic symptoms dependent upon this condition.

Pathology.—The pathology of posterior urethritis is complex, as the lesions must be considered from the viewpoint of changes in the mucous membrane, and also in the adjacent organs which drain, by ducts, into this portion of the urethra, and through which channels they become infected. The symptoms depend more often upon pathological changes in the prostate and seminal vesicles, than upon those in the mucous membrane, yet all are usually involved in a common inflammatory process.

The early *mucous membrane changes* are slight swelling, edema and congestion, desquamation of the epithelium, and a submucous round-cell infiltration, which, however, in the repair process does not proceed

to any material narrowing of the canal by the deposit of fibrous tissue, an explanation of this fact being that the walls of the posterior urethra are normally fixed by the surrounding structures, and it is a well-known fact that stricture of the posterior urethra, as a result of gonorrhea, is practically unknown.

The important pathology of chronic posterior urethritis is the extension of the inflammation, through connecting channels, to the sinus pocularis and particularly to the prostate and seminal vesicles.

When the *sinus pocularis* is invaded by infection, drainage is often inadequate and a chronic suppuration, in consequence of this fact, is often the cause of persistent symptoms, both in regard to indefinite perineal pain and a persistent urethral discharge.

Chronic prostatitis is the most common complication of a posterior urethritis. The prostate being composed of numerous glandular tubules which empty into the posterior urethra, by minute ducts, once becoming infected, harbor the organisms over long periods of time, often years; exacerbations of acute symptoms are prone to occur with lowered local or general resistance, and infection of other individuals through intercourse, is more often due to an infectious chronic prostatitis than to any other chronic inflammatory change in the genital track. Within the gland's tubules there is a proliferation and desquamation of epithelial cells, together with a discharge of pus cells and detritus, which, collecting in the minute tubules, adhere together and form small plugs, obstructing the canals in some degree, and interferes with the drainage of the prostatic section and products of inflammation. By so obstructing the tubules, the prostatic secretion and products of inflammation are dammed up in the acini of the gland so that the ducts and their glands become more or less dilated with these products. The plugs because of the pressure behind them are forced through the ducts, which, being surrounded by a round-cell infiltration and connective-tissue elements are more or less rigid, into the prostatic urethra and appear in the urine as small comma or hooked-shaped shreds or granular bodies.

The chronic inflammatory process within the gland may be limited to one or both lobes, or only certain segments of a single lobe of the gland may be involved. Drainage of a segment of the prostate may be so impaired as to dilate the tubules and acini into small cysts or areas of retained secretion and products of inflammation; and as the intertubular fibrous elements of the fibromuscular stroma, which comprises a large part of the gland structure are increased, isolated areas of prolonged infection within a segment of the gland may become more or less encapsulated, and this area in the prostate becomes clinically nodular by rectal palpation. Occasionally the chronic infection may extend to the prostatic capsule, increase the connective-tissue elements of which it is chiefly composed, and even invade the soft tissues surrounding it, and thus bind it more or less firmly to the rectum by scar tissue (periprostatitis). This condition is of surgical importance in performing the operation of exposing the prostate and seminal vesicles.

Chronic Seminal Vesiculitis.—This condition is due to infection passing from the posterior urethra up the ejaculatory duct to the seminal vesicles. The ejaculatory ducts are never occluded by chronic inflammatory changes, yet their walls become somewhat thickened by infiltration, and may become so rigid as to lose the function of closing completely so that secretion is constantly escaping (spermatorrhea).

From a study of a large amount of material removed at operation we have observed that one vesicle, and not the other, may become involved; and that chronic inflammation may not involve the whole organ, but more often occurs in areas only. The epithelial lining of the cavities affected is often lost; there is an active desquamation of epithelial cells, which together with polymorphonucular and endothelial leukocytes, gland secretion and detritus, more or less fill the tubular spaces. The walls of the tubules, the tunica propria and muscularis are densely infiltrated with similar leukocytes, plasma cells and eosinophiles. Unless the inflammatory process is extensive, there is but little increase in the connective-tissue elements; but when the process is extensive, the fascial coverings of the vesicles show considerable connective-tissue proliferation, resulting in infiltration and thickening. The gross pathology as demonstrated *in vivo* when operating upon the seminal vesicles has demonstrated that a perivesiculitis may be present with thickening of the fascia Desnonvillier by scar tissue.

Symptoms.—The symptoms of chronic posterior urethritis are usually a chronic persistent urethral discharge, with or without indefinite nervous and mental disturbances of a sexual nature, attributable to inflammation or excessive congestion of the verumontanum. It is sufficient to say that the sexual disorders are a variable feature; the act of coitus being unsatisfactorily performed, either from premature ejaculation, or even inability to perform the act. Nocturnal emissions are common, and the constant irritation in the posterior urethra, dependent upon the chronic inflammation, often causes the individual to become focussed on sexual matters, and produces the state of mind commonly called sexual neurasthenia.

Diagnosis.—The important symptom as regards diagnosis is the presence of a chronic urethral discharge, more or less purulent in character, which has been proved, by examination, through instrumentation and endoscopy, not to originate in the anterior urethra.

If the mucous membrane of the posterior urethra is much congested, and in a hypersensitive state; urination may be frequent, somewhat painful, and bleeding is apt to occur easily on even the gentlest instrumentation. These cases are in the minority, and are usually those with a posterior urethritis not due to gonorrhea, but sexual perversions of one sort or another, producing changes in the colliculus or verumontanum.

The majority of the patients with posterior urethritis, of gonorrheal origin, do not possess this hypersensitive condition of the posterior urethra and the train of nervous and mental symptoms dependent upon it, but have a persistent urethral discharge, more evident in the

morning than at any other time, and if they did not have the persistent discharge would not consider that there was anything the matter with them. Most, if not all, of these patients have a chronic prostatitis, seminal vesiculitis, or both in varying degree, with little or no important changes in the mucous membrane of the deep urethra or colliculus.

The diagnosis of chronic posterior urethritis depends upon an examination of a smear of the material at the meatus; the two-glass test, eliminating lesions in the anterior urethra by instrumentation for urethral narrowing and endoscopy of the anterior and posterior urethra, palpating the perineum for a Cowperitis, the prostate and seminal vesicles for gross changes, collecting the material expressed from the prostate and seminal vesicles, and the urine after massage for microscopical or bacteriological study. If necessary, in questionable cases, to determine whether or not the condition is dependent upon gonorrhea, blood may be taken for a complement-fixation test.

The *smear from the meatus* will show pus, sometimes gonococci or other organisms; most commonly the staphylococcus, epithelial cells, possibly of several varieties, but particularly the small round prostatic cells, prostatic secretions and detritus. If the inflammatory process has largely subsided, the discharge may be chiefly prostatic epithelial cells, prostatic secretions and detritus, but without pus or organisms, the condition usually termed *prostatorrhea*. This discharge usually appears at the meatus after stool or urination, and is an expression of the result of a chronic posterior urethritis, prostatitis, or vesiculitis, rather than an active chronic inflammation. If the smear contains spermatozoa, masses of mucus and phosphates, one realizes that they come from the seminal vesicles, and not from the prostate. The latter condition is termed *spermatorrhea*. Such elements from the vesicles may be associated with those observed in prostatorrhea, and, as in that condition, is simply evidence that the ducts communicating with the posterior urethra have lost their function and remain more or less constantly open.

The Two-glass Test.—If the inflammatory process is at all active, both urines will be more or less cloudy, but at a later stage both may be clear or nearly so, and the first urine will contain by far the greater number of comma and smaller granular shreds, the plugs from the prostate. Albumen is often found in the urine, due in great part to the prostatitic and seminal vesicle secretion contained in the urine. The presence of albumin in the urine of patients with a mild chronic prostatitis or vesiculitis, undergoing an examination for life insurance, is often misinterpreted. Phosphates are commonly observed and the elements of a mild basal cystitis are not uncommon when the seminal vesicles harbor chronic inflammation.

Endoscopy in chronic posterior urethritis, except in long standing cases, frequently causes fresh bleeding. The mucous membrane is observed as markedly congested, especially about the colliculus, which is usually swollen, and particularly is this the condition noted in those with sexual symptoms. Small polypi are sometimes observed

springing from the colliculus and pus may be observed coming from the opening of the sinus pocularis or its mouth plugged with fibrin. The same is true of the opening of the ejaculatory ducts.

Palpation of the Prostate and Seminal Vesicles.—The findings in the examination of the prostate will vary according to the stage of the process, and the amount of the prostate involved. In the early stages of chronic prostatitis, one, but more often both lateral lobes of the glands are usually boggy, soften to some degree by massage, and deep areas, harder than most of the tissue, may be detected; and represent a connective-tissue repair process with dense fibrous tissue about the more active foci of infection. In the late stage the gland is little if any enlarged, is harder than normal, due to a more general fibrous change in the intertubular elements, nodules of varying size may be present, and when the process has invaded the prostatic capsule and surrounding tissue, resulting in a periprostatitis, the gland being imbedded in it, is indefinite in outline.

The seminal vesicles, unless much involved, may escape detection by palpation, except by those most experienced. When they are distended, their walls thickened or a perivesiculitis exists, they may be detected, often apparently connected with the outer superior border of the prostate, with which they may appear to be continuous. Only the lower portion of the seminal vesicles can be reached by the examining finger, and the detection of a distended vesicle cannot often be considered as pathological, and, as with the prostate, the diagnosis must depend rather upon the expression of the secretion and examining it microscopically than by palpation alone.

Examination of the Material Expressed from the Prostate and Seminal Vesicles.—Although prostatic secretion may be expressed from the normal prostate, the amount is much increased in chronic prostatitis, often being two to five times normal in amount; the normal amount being about 5 c.c. It is the microscopical examination of the fluid expressed that should form the basis of understanding as regards the condition of the prostate; quite as much as the examination of the urine is necessary to understand the condition within a kidney, which may be palpated. The material expressed from the prostate and seminal vesicles should be collected in a clean glass receptacle, preferably a staining dish, by holding it at the meatus during the massage. A gross inspection of the expressed fluid is of value in determining its amount and gross character. The normal fluid, about 5 c.c. in quantity, appears not unlike the unboiled white of an egg, or slightly pearl colored, but is a homogeneous fluid without particles. If the prostate is diseased, minute chunks or particles, many in the form of comma shreds, are observed, if the inflammatory process in the gland is of long standing; but if there are any suppurative areas still present, the material may appear purulent, and sometimes streaked with blood.

The *microscopical examination* of the fluid expressed will vary as does the gross appearance, dependent upon the activity and stage of the disease. If the process is active, pus cells are numerous, as are prosta-

tic cells. Gonococci may not be present in a single examination yet found in subsequent ones, and their absence should not imply that they are not still within areas of the gland, which are not draining or opened by massage, and the presence of pus without gonococci, on several examinations, should not lead to the belief that the patient is non-infectious. So long as numerous pus cells exist a contrary view must be held.

The *material expressed from the vesicles* is usually mixed with that of the prostate. It may, however, be distinguished in the gross, from that part originating from the prostate, by its thick globular jelly-like character, conforming, in some measure, with the cavity of the vesicle from which it has been expressed. Blood, even fresh and staining the whole massage fluid, or old blood of chocolate color, more often come from a chronic inflamed vesicle than from the prostate.

Microscopically the elements, aside from pus and organisms, throwing suspicion upon the vesicles rather than the prostate, are living or dead spermatozoa, fine granular vesicular cells, columnar and squamous epithelial cells, hyalin, amyloid bodies and spermatic crystals. The differentiation as to whether the predominating pathological elements are from the vesicles or prostate is of no practical importance, as it has been sufficiently proved that when inflammation exists in one it exists also in some degree in the other organ, and treatment, either non-operative or operative, should be directed to both the vesicles and prostate.

The *urine voided after prostatic and vesicle massage* is usually cloudy from an admixture of the expressed secretions, which runs back into the urine in the bladder, or remain in the urethra. Pus, in amount varying with the activity of the process, comma shreds and fine granular and small chunky masses are the most common. It will be found by comparing the first urine passed, the massage fluid, and the urine passed after massage that the same elements, particularly pus and comma shreds will be present in all, if chronic inflammation exists in the prostate and vesicles. The microscopical examination of the sediment will disclose the same elements as are contained in the prostatic and seminal secretions.

Albumin, sometimes in large amounts, will be present in the urine passed after massage; even if it is absent in that passed previous to it, for the obvious reason that the prostatic and vesicle secretions are albuminous in character.

Prognosis.—The essential feature in prognosis is in regard to whether or not the patient can be made non-infectious and should be allowed to marry.

In patients without mental or psychical disturbances the prognosis is not unfavorable, and it may be stated that the individual can be freed from infection by persistent and intelligent treatment, which may, however, need to be extended over a period of many months.

In the group with mental and psychical disturbances of a sexual character, dependent upon chronic inflammation of the posterior

urethra, the prostate and vesicles, the prognosis is not so favorable in regard to the overcoming these secondary symptoms. In many, however, the symptoms subside and disappear, as the lesions, dependent upon the posterior infection, are cured.

Relapses of symptoms, especially the return of discharge, usually without the presence of the gonococcus or other organisms, are prone to occur, especially from a lowered general resistance following some acute disease, such as pneumonia or influenza.

The *patient may be considered cured* when there is no urethral discharge, or a discharge is proved to be that of prostatorrhea or spermatorrhea, which implies no gonococci, pus, or other organisms, and the absence of pus cells or organisms in the secretion expressed from the prostate and vesicles on at least five occasions at weekly intervals while the patient is leading a normal existence, and when the anterior urethra shows no lesions by endoscopic examination and freedom from stricture.

A negative complement-fixation test is an additional feature which may be employed in this connection, but a period of two months must be allowed to elapse before a negative finding may be expected, even after the infection has disappeared. Cultures for the gonococcus in any fluids obtained from the genital tract are of questionable value, because of the difficulty in growing the gonococcus and the tendency for other organisms, not pathogenic in the urethra, to grow abundantly.

Treatment.—The treatment of chronic posterior urethritis depends upon the severity of the degree of infection and whether or not the prostate, colliculus, sinus pocularis, prostate, or seminal vesicles have participated in the process.

In the mild cases of chronic posterior infections in which the mucous membrane shows erosion, edema and infection, and the gonococcus but without infection of the prostate and vesicles, the lesions are best treated by irrigations by means of forcing antiseptic fluids, freshly prepared argyrol 5 per cent., and protargol 1 per cent., from the meatus to the bladder by means of a nozzle either of an irrigator or syringe held tightly at the meatus, until the bladder is filled, at which time the patient voids the bladder contents. This should be repeated at least twice, and two ounces of the fluid allowed to remain in the bladder.

When *the gonococcus is not present* an irrigation, either by gravity or by syringe, in the way just described, but employing potassium permanganate 1 to 6000 to 1 to 3000, or silver nitrate 1 to 10,000 to 1 to 2000, are more beneficial.

When *the colliculus gives symptoms*, especially those of a sexual character, in connection with a posterior urethritis, and the examination through the deep endoscope shows it to be enlarged, congested, or the site of polypi, it should be cauterized with silver nitrate, either by means of a swab moistened in 25 to 50 per cent. silver nitrate, or with a silver nitrate stick; the galvano-cautery, or destroyed by fulguration. If benefit is not received after several treatments by these methods, it may be cut away by means of special Rongeur forceps,

through the endoscope, or curetted away through a medium perineal urethrotomy incision.

If the sinus prostatis is *harboring chronic infection* without sufficient drainage through its duct, this opening should be enlarged by incising it through the deep endoscope and swabbing or injecting its cavity with antiseptics by means of a special instrument. This procedure should be repeated every few days according to the reaction, and should be combined with massage of the prostate to empty the cavity by pressure.

When *the prostate and vesicles are involved*, as they are in the great majority of cases of posterior urethritis, the treatment consists in having the patient ingest large amounts of water and to urinate once an hour during the day, and as frequently as possible during the night, in order to constantly wash the urethra free from the products of inflammation, and to help to keep the prostatic ducts, opening into the posterior urethra, from becoming plugged with the products draining from the infected portions of the gland.

The diet, as in all acute and chronic inflammation in any part of the urinary tract, should be made non-irritating by eliminating condiments, alcohol, carbonated waters, and acid foods. The bowels should not be allowed to become constipated, and sexual excitement should be prevented; except in mild cases of long standing where the process is very chronic, when intercourse in moderation, but wearing a condom may be considered beneficial by so emptying the prostate and vesicles of the retained products of inflammation and secretions. Rectal massage, as a rule every third day, should be done, preferably, on a full bladder, and following the massage the urethral tract is washed by the voiding of the urine. The anterior urethra should then be made clean by an injection of some antiseptic fluid, preferably permanganate of potash, and an instillation of argyrol 25 per cent., or other silver preparations in glycerine, by employing a Keyes-Ultzmann syringe, should be injected into the deep urethra and allowed to remain for about two hours before urinating. If, however, the material expressed from the prostate and vesicles is in the least purulent, the instillation should be substituted by an irrigation of a 5 per cent. argyrol solution, from the meatus to the bladder; subsequently voiding it and the process repeated at least twice, leaving two ounces of the argyrol in the bladder, where it should be held for at least an hour.

The progress during treatment may be determined by the gross and microscopical examination of the fluid expressed from the prostate and vesicles. In a general way the use of argyrol or some silver equivalent is to be employed while organisms are present, and potassium permanganate and occasionally silver nitrate after they have disappeared. The more acute cases should receive irrigations, and the more chronic cases, without organisms and little pus, instillations are considered preferable. The value of glycerine, in the medication instilled, is its depleting property. The treatment should be continued as long as pus is present, and when the fluid expressed from the prostate and

vesicles contain but few leukocytes and no organisms, the local treatment may be dispensed with; but every attention to keeping the bowels from becoming constipated and the urine from becoming concentrated should be matters to receive attention for a period of many months following the subsidence of all symptoms as relapses are prone to occur.

During the treatment by massage, irrigation or instillations, occasional dilatation of the deep urethra, as well as the anterior urethra, should not be neglected, as a submucous infiltration dependent upon the early lesions may result.

There are certain patients who cannot be cured of the infection in the prostate, and especially in the vesicle, by the method of treatment just outlined; and in such individuals in whom the symptoms persist over periods of many months the advisability of vesiculotomy or vesiculectomy with drainage of the prostate must be considered. The Belfield operation, which consists of opening the vas deferens in the scrotum and irrigating the chronically infected vesicles with an antiseptic fluid has proved of value in some instances, but only when the process is chiefly confined to the vesicles. It has no influence upon the prostate infection, and while the writer has come to consider it valuable in certain of these cases, it is attended by failure to produce a cure in many, and has frequently had to be followed by a vesiculotomy or vesiculectomy with prostatotomy to effect a cure.

The use of gonococcus vaccine in chronic prostatitis and vesiculitis without metastatic gonorrheal arthritis is considered to be of little or no value.

Surgical Complications of Chronic Posterior Urethritis.

These consist of chronic inflammation of the seminal vesicles and prostate, with or without recurrent exacerbations, which cannot be cured by non-operative methods. The persistence of chronic inflammatory lesions in the seminal vesicles and prostate also explains most cases of recurrent epididymitis, and it has been sufficiently proved that metastatic gonorrheal arthritis originates from foci of infection located in these structures.

While the majority of patients with chronic inflammation in the seminal vesicles and prostate can be made non-infectious, and most of them cured by non-operative methods, it is, nevertheless true that there are some which cannot, and in whom remissions of acute symptoms repeatedly occur. For these patients, Belfield's operation, which consist of a vasotomy and irrigation through the vas deferens, of the diseased seminal vesicles, and vesiculotomy or vesiculectomy with a prostatotomy is necessary to produce a cure. In many of these cases the Belfield operation has proved beneficial, yet there are some that cannot be cured by any procedure short of thorough drainage or removal of the seminal vesicles, and a prostatotomy or partial prostatectomy.

When gonorrheal metastatic arthritis exists as a complication to

chronic seminal vesiculitis and prostatitis the Belfield operation has been of no value, but most brilliant results follow vesiculotomy, vesiculectomy and prostatotomy. Treatment of gonorrheal metastatic arthritis, erroneously called gonorrheal rheumatism, in the form of local joint applications, fixation, baking, local urethral medications and irrigations, together with gonorrheal vaccine has been of benefit in some of the milder cases; yet a permanent cure has been rare. The opening and washing out of infected joints has been occasionally

FIG. 261.—Acute infectious periostitis of gonorrheal origin, showing proliferation of the periosteum and spur formation on the central surface of the os calcis (usually bilateral).

beneficial, but on the whole the results have been poor, and such treatment as opening the joint has now been discarded in view of the realization that a cure only results from the removal of the foci in the seminal vesicles and prostate from which the metastatic arthritis occurs. The removal of the foci of infection in the seminal vesicles and prostate, when metastatic gonorrheal arthritis exists, is followed by an almost miraculous improvement in the acute manifestation of the joint complication. If destructive lesions, in the form of erosion of cartilage, atrophy of bone, or a periostitis exists in the form of spurs,

not commonly on the os calcis, these should be removed, and time must be allowed for destructive lesions to be repaired, aided by fixation, etc. The removal of the foci of infection causes a cessation of the infectious process within joints, and this treatment has changed what was previously a most hopeless condition into one of the most brilliant surgical results.

Belfield's Operation.—This operation is applicable, and possibly beneficial, in cases of chronic inflammation in the seminal vesicles, which cannot be made non-infectious or cured by non-operative methods of treatment.

The operation consists of exposing the vas deferens, under local anesthesia, through an anterior or lateral incision in the scrotum. The vas deferens being drawn out of the wound is opened and the lumen explored upward, as far as possible, by a strand of silkworm gut. A syringe containing three drams of a 10 per cent. argyrol or collargol solution, and fitted with a blunt needle, is introduced into the lumen of the vas deferens, and the fluid slowly injected, with the aim in view to wash out the seminal vesicles, kill infection, and to allay inflammation within it. In order that the opening of the vas may be accessible for subsequent injections a strand of catgut, which will pass into the opened lumen, is introduced upward for about one-half inch, and the other end is left protruding from the wound. Both sides may be operated upon at the same sitting, and while much has been claimed, in the way of results, from a single injection, it has been the writer's practice to make daily injections for three or four days when this operation has been employed.

If the vas deferens is completely divided through necessity or accident, the cut end may be united and the lumen restored by passing a fine catgut suture threaded on a fine needle into the lumen of each cut end of the vas, piercing the wall about one-quarter of an inch from each cut end so that the vas deferens is threaded onto the suture, and by drawing on each end of the suture the cut ends of the vas comes in apposition, assuring the continuity of the lumen. The ends of the catgut suture are loosely tied outside of the wound, and after six days the knot may be cut and the suture withdrawn, leaving a patulous lumen of the vas deferens.

If the vas deferens has simply been opened, and not severed, it may be dropped back into the scrotum when the treatment has been completed, and the wound closed by one or two interrupted silkworm-gut sutures. Considerable experience with this operation tends to prove that occulsion of the vas deferens does not usually occur from it. If, however, it is felt that the vas has been unduly traumatized, the procedure described for the union of the cut ends of the severed vas should be employed.

Seminal Vesiculotomy or Vesiculectomy with Prostatotomy. — This procedure is to be carried out when acute or chronic inflammation is present in these structures, which cannot be cured by non-operative methods or the Belfield operation, and is the only procedure to be

employed as operative treatment in gonorrheal metastatic arthritis. This procedure was first advocated by Dr. Eugene Fuller in 1901, but with an entirely different technic from that here presented.

Dr. Fuller's classification of patients in whom this operation is indicated includes not only those with chronic suppurative lesions in the seminal vesicles and those with metastatic gonorrheal arthritis,

FIG. 262.—Skin flap dissected and retracted downward, exposing bulb of the urethra and the median perineal tendon. On either side of the median tendon the openings into the ischiorectal fossa are seen. Insert shows outline of skin incision.

but also those with neurasthenic symptoms, the sexual neurasthenic, and those with persistent or intermittent perineal pain, due to lesions in the seminal vesicles. The writer cannot speak with authority in regard to the benefits of this procedure in the sexual neurasthenic or pain groups. There remains no question, however, in the mind of the writer that certain cases of chronic inflammation of the vesicles and

prostate cannot be cured except by seminal vesiculectomy or vesiculotomy and prostatotomy, and that this procedure is the only one which promises permanent benefit in metastatic gonorrheal arthritis.

FIG. 263.—The index and second fingers of the left hand inserted into the fossæ, holding the rectum downward, while the median tendon and recto-urethralis muscles are divided. Dotted line on perineal tendon shows line of incision.

The examination of a considerable amount of pathological material collected at operation has shown that inflammation not only exists in the seminal vesicles but also in the prostate as well. And for this reason the prostate should receive attention as well as the seminal vesicles.

Technic.—The patient is placed in an exaggerated lithotomy position. An inverted V-shaped skin incision is made following the bony arch of the pelvis, the apex in front over the bulb of the urethra, and the

lateral incisions extending backward to the tuberosities of the ischium. The skin flap so outlined, and including fat, is dissected from the underlying structures, exposing the bulb of the urethra and the perineal tendon. The fossa on either side of the medial tendon is opened, as

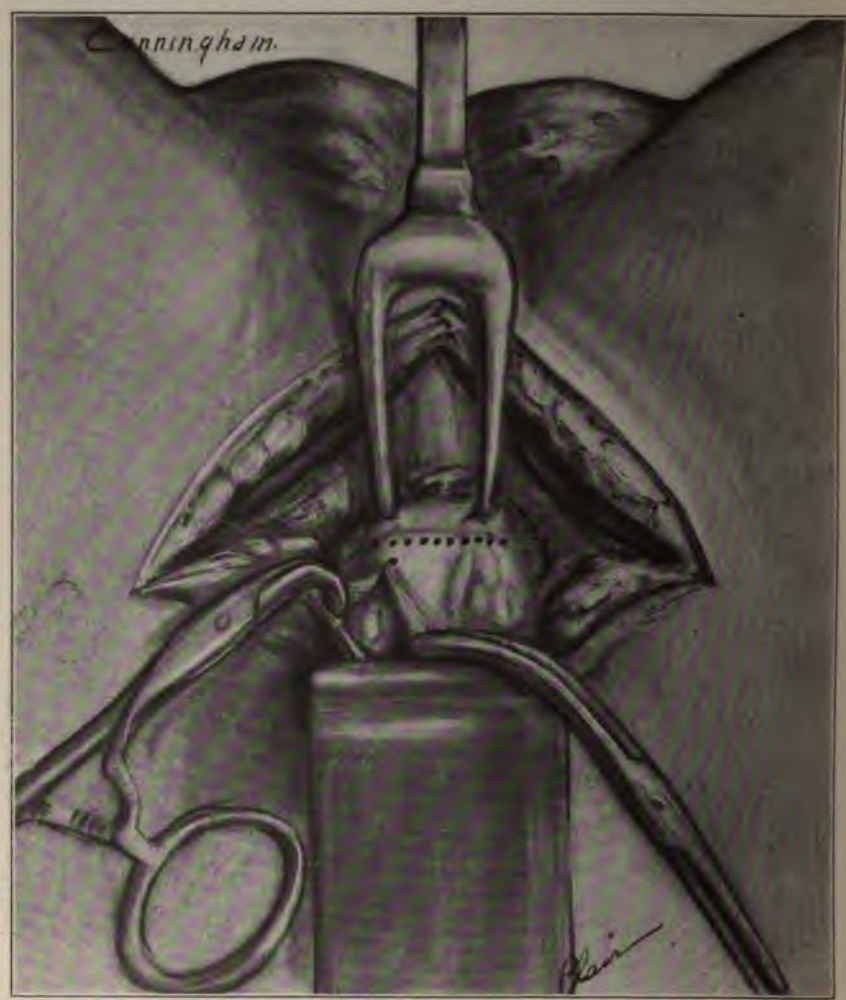

FIG. 264.—Special double tenaculum inserted into the prostate just in front of the junction of the prostate with the bladder, elevating the prostate and exposing the vesicle area. One vesicle is seen showing through the fascia of Desnonvillier; and on the other side the fascia divided and retracted, exposing the vesicle. At the bottom of the wound is the special retractor placed over the rectum.

deep as possible, by blunt dissection with the index finger, identifying the apex and the posterior surface of the prostate and freeing the rectum from it, as much as possible (Fig. 262). The median tendon and recto-urethralis muscles, which attach the rectum to the urethra, are divided

as near the bulb of the urethra as possible. With division of these recto-urethral attachments, the muscular fibers of the levator ani muscle may be seen attached to the posterior surface of the prostate. These fibers are freed by blunt dissection, from the posterior, and partly from the lateral surface of the prostate. The blunt dissection is carried

FIG. 265.—The drainage tubes caught in the structure of the vesicles by a catgut suture and the incisions into the prostate tissue. Both vasa deferentia are seen between the tubes. Insert shows in detail the opened ducts of the vesicle with sutured tube in position, the opened vas deferens and the retracted fascia of Desnonvillier.

beyond the junction of the prostate with the bladder, exposing the vesicle area and the base of the bladder (Fig. 263). The rectum is protected by a piece of gauze placed to the bottom of the wound and a flat retractor, either 1½ or 2 inches in width, according to the width of the bony pelvis, and with an abrupt curve and long enough to reach the bottom of the wound, is inserted. This special retractor is furnished with a weight

so that it is self-retracting. The posterior surface of the prostate and bladder are now visible. A special double tenaculum is inserted into the prostate tissue just below its junction with the bladder. By lifting the prostate with this instrument the base of the bladder and the vesicle may be visible beneath the fascia of Desnonvillier, provided this

FIG. 266.—The wound closed by interrupted silkworm-gut sutures, with drainage tubes at either angle of the wound, also the rectal plug made of rubber tubing and gauze.

fascia is not much thickened by inflammatory infiltration (Fig. 264). Even when not visible the sulcus in the median line, between the vesicles, may often be palpated, which, however, is not necessary if the dissection is carried well above the superior border of the prostate. The fascia in the vesicle area, on first one side and then the other, is picked up

with forceps and divided thus exposing the vesicle, or an incision of the fascia just above, and parallel with, the superior border of the prostate may be made. This flap of fascia may be pushed back by blunt dissection, and not only the vesicles, but the vas deferens on both sides may be recognized. The fascia covering the vesicles varies greatly in thickness, being normally as thick as writing paper, may be nearly one-quarter of an inch thick when involved in extensive perivesiculitis. While there is usually a line of cleavage between the fascia and the vesicle, they may be so bound together that the vesicle must be opened without freeing the fascia from it. The vesicle being exposed, it may be freed and removed, or opened by multiple incisions, or better by cutting away the posterior wall and thus giving it freer drainage, or they may be removed. If a vesiculectomy is to be performed it is greatly facilitated by placing a snap on the vas deferens, and drawing downward on it while working around and beneath the vesicle with curved scissors. If the ampulla of the vas is dilated it also should be incised. When a vesiculotomy is done the vesicle should be well opened, its interior swabbed with crude carbolic acid, followed by alcohol. Small rubber drainage tubes are caught in its structure by a No. 1 plain catgut suture (Fig. 265). The prostate tenaculum is removed and the prostatic capsule freely incised over each lateral lobe, a section removed and several incisions made into the remaining prostate tissue, as it is believed that infection lurks therein to some degree in nearly, if not all instances of seminal vesicle infection. The retractor and gauze protecting the rectum is removed and the rectum inspected to be sure that it has not been opened and if so it should be immediately repaired. The divided perineal tendon is united with catgut.

After the divided muscles and the median tendon have been united, the skin-flap is replaced and the wound closed by interrupted silkworm-gut sutures, and the drainage tubes, sutured into the opened vesicles in a vesiculotomy or to the bottom of the wound if a vesiculectomy has been done, protrude from either angle of the wound. A rectal plug four inches long, composed of rubber tubing surrounded by iodoform gauze, is inserted into the rectum and held by a suture to the anal margin (Fig. 266). In this way the rectum is made to occupy its normal position and closes the space above the muscular repair. By filling this space in this way oozing is less apt to result in an accumulation, and the rectum being held open by the tube, allows the escape of gas during the period that the bowels are confined.

A scrotal dressing which holds the testicles well elevated is applied to prevent the possibility of epididymitis, which is prone to occur. A dry dressing is applied and held in position by a "T" bandage.

The after-care consists in keeping the patient on a light diet, the administration of pill opii, grain one, morning and night, for five days, in order that no movement from the bowels may occur. On the fifth day the pill opii is omitted; on the sixth day the rectal plug is removed and an oil enema of two ounces is injected into the rectum through at long-nosed syringe or catheter and a dose of castor oil administered.

The patient is then placed on a more substantial diet. One or more antiseptic dressings are applied to the wound daily, and the drainage tubes are allowed to remain seven days. The areas occupied by the tubes usually heal in from three to five days following their removal. A suspensory bandage should be worn for a period of at least one month. Any remaining evidence of prostatitis or anterior urethritis should receive appropriate local treatment.

PERIPHERAL NERVE LESIONS, CLINICAL AND SURGICAL CONSIDERATIONS.

By DEAN LEWIS, M.D.,

AND

LEWIS J. POLLOCK, M.D.

Before discussing the various operative procedures which are employed to restore the continuity of a nerve that has been divided or to promote the return of function of a nerve which has been interfered with or completely suspended as a result of injury or compression by scar tissue, bony callus or adhesions a brief resumé of the changes which occur in a nerve after division and during regeneration will be given.

There has been considerable discussion from time to time concerning the regeneration of peripheral nerves. Within fairly recent times it has been contended by some that neurofibrillæ, the conducting element of the nerve, might develop within the distal segment of a divided nerve. If such were the case, the union of a divided nerve by first intention with almost immediate or at least very rapid restoration of function might occur. We believe that no definitive regeneration of neurofibrillæ ever occurs in the peripheral segment of a divided nerve. All definitive regeneration of neurofibrillæ occurs from the proximal segment; the developing neurofibrillæ proceeding distalward in newly-formed protoplasmic bands or in old empty sheaths of the distal segment to supply the muscles or terminal sense organs to which they are finally distributed.

After division of a nerve abortive regenerative changes are observed in both segments adjacent to the plane of section during the first two or three days. These consist of an outgrowth of fine terminal and lateral neurofibrillar rami from both the medullated and non-medullated fibers; of the dissociation of axis cylinders into bundles of fine neurofibrillæ and of the development of delicate plexuses of such fibrillæ beneath the neurilemmal sheaths. These abortive fibers of regeneration appear in both the proximal and distal segments, but only in the immediate vicinity of the plane of section. They degenerate completely in from three to eight days.

Wallerian degeneration, which we believe plays an important rôle in nerve regeneration, occurs throughout the entire distal segment. In this degeneration the neurofibrillæ become swollen and later fragmented and granular. Finally the neurofibrillæ disappear. The myelin becomes broken up into masses and globules to be partially

absorbed or removed. Associated with these degenerative ch in the neurofibrillæ and myelin are regenerative changes in the n lemmal sheaths which apparently play an important rôle in regeneration.

The adult neurilemmal sheath (Schwann) is a fine, thin, struc less membrane, almost invisible. It is provided with a few fus nuclei—one to each node of Ranvier, which vary in length 80 to 900 μ in diameter. These nuclei are surrounded by a amount of cytoplasm. Mitoses are not found in the resting

FIG. 267.—Section of normal nerve, showing number of neurilemmal nuclei (Kirk and Lewis.)

Soon after division of a nerve very definite changes occur i sheaths adjacent to the plane of section. These changes are obs in both the proximal and distal segments. The first change co of a slight increase in the amount of granular cytoplasm surrou the nucleus. This change is observed within twenty-four to thir hours in the sheaths adjacent to the plane of section. Durin following days the cytoplasm increases rapidly in amount, the n increase in number as the result of mitosis and by the fourth to days the protoplasmic bands—the result of these changes—

become well developed. These bands are narrow strands of cytoplasm which contain the now hyperchromatic and active neurilemmal nuclei.

Experimental work would seem to have demonstrated that these protoplasmic bands form conduits or pathways along which the developing neurofibrillæ, which always originate in the neurofibrillæ of the proximal segment, pass to reach their terminal distribution. Undoubtedly developing neurofibrillæ can reach their terminal distribution without the aid of protoplasmic bands. Clinical evidence would seem to show that the bands play an important rôle in nerve

FIG. 268.—Section of distal segment of a nerve six days after division, showing increase in neurilemmal nuclei. *a* represents protoplasmic band. (Kirk and Lewis.)

regeneration, for the spinal cord and optic nerve, which are not provided with neurilemmal sheaths, never give any clinical evidences of regeneration after division.

The neurofibrillæ, the essential conducting element of the nerve, develop from the neurofibrillæ of the proximal stump and grow distalward. They develop in excess of the number required to neurotize the distal segment. All regenerating fibers whether the outgrowth medullated or non-medullated fibers are, in their early stages, non-medullated. Medullation first appears proximally. It proceeds

distally, appearing first in fibers which are five or five and a half weeks old (in the dog).

As nerves regenerate by a downgrowth of neurofibrillæ from the central stump a certain time is required after suture before function can be reëstablished. The reports of early return of function after suture are based upon imperfect or inaccurate observations which were made before the suture was performed or upon the misinterpretation of supplementary movements.

In all surgical procedures having as their object the reëstablishment of the continuity of a nerve an accurate end-to-end suture should be made whenever possible. Scar tissue and hematomas which prevent

FIG. 269.—Protoplasmic band containing non-medullated axis cylinders, the latter stain- black. (Kirk and Lewis.)

the developing neurofibrillæ from penetrating and neurotizing t distal segment should be eliminated as much as possible.

The following operations: Neurolysis, nerve suture (neurorrhaphy nerve transplantation, nerve grafting and tubulization, must be co sidered when discussing the surgery of peripheral nerves.

Neurolysis is an operation which consists of dissecting the affect nerve out of the scar tissue or bony callus which surrounds and co presses it and of providing the liberated nerve a new bed free from sc tissue, or of surrounding it with some material which may prevent t reformation of scar tissue and subsequent interference with the fu tion of the nerve. When the nerve is incised and an attempt is ma to liberate the funiculi from scar tissue within the nerve proper, t

operation is referred to as *internal neurolysis*. Removal of the thickened epineurium with the adherent scar tissue is often referred to as *capsulectomy*.

Neurolysis was first performed by Busch and Ollier in 1863. Busch performed neurolysis upon a nerve which was compressed by scar tissue and Ollier dissected a nerve out of the bony callus which compressed it.

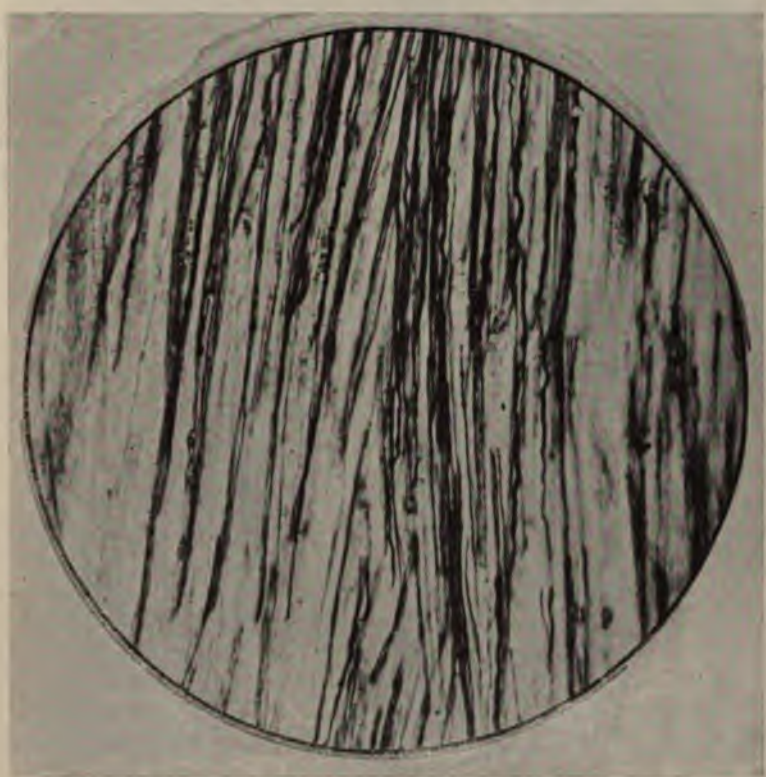

FIG. 270.—Regeneration of axis cylinders from proximal segment and represents bulbs on ends of fibers from which new fibers develop. These develop in excess of those actually required to neurotize the distal segment. (Kirk and Lewis.)

All surgeons are not agreed as to the value of neurolysis. Some believe that it is better in doubtful cases to resect the nerve at the site of the lesion and to perform a nerve suture than to be satisfied with neurolysis. Others believe that the results are not much better after neurolysis than when the injured nerve is let alone. The disagreement as to the value of the operation is due in part to the fact that it has been performed in cases in which it has not been indicated. It has undoubtedly frequently been performed when resection of the injured portion of the nerve with subsequent suture should

have been resorted to. It is often impossible to state whether th return of function is due to neurolysis, for in many cases it is quit possible that the nerve would have recovered function if no opera tion had been performed. Many cases of nerve injury presenting a the symptoms associated with degenerative changes suddenly mar fest evidences of improvement and proceed to rapid recovery.

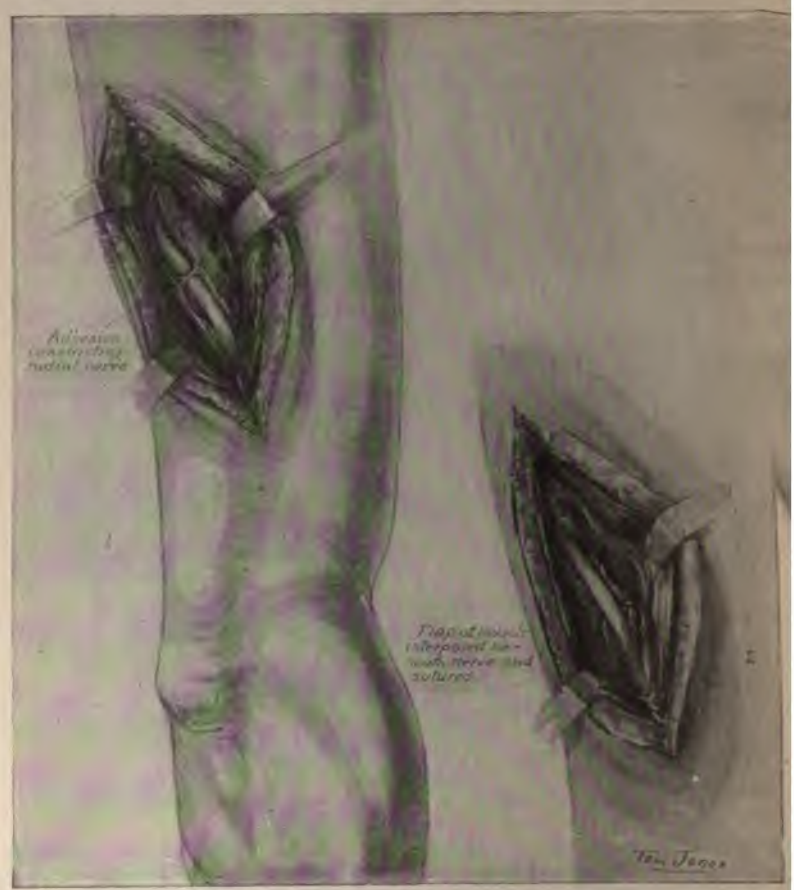

FIG. 271.—Complete physiological interruption of left musculospiral nerve due to delicate constricting band, following a penetrating wound by a piece of an explosi shell. In this case there was also a fracture of the humerus. Excision of the sca followed by muscle neurolysis, was performed. First evidence of return of motor pow noted in ten days. (Lewis, Surgical Clinics of Chicago, August, 1919, No. 4, iii, 1

neurolysis were performed at the time this improvement was abou to begin, the credit would naturally be given the operation and sti it would be difficult to determine what relation it actually bore to th rapid improvement.

The operation is indicated in those cases in which the lesion extraneural and in cases in which an extraneural is combined with a

intraneural lesion which is not severe enough to destroy or interrupt completely the funiculi. The operation is particularly indicated in those cases in which the interference with or suspension of function is due to compression by scar tissue, bony callus, or constricting bands. Whether neurolysis or suture should be attempted depends upon the gross appearance of the nerve; the feel, whether indurated or not, and upon the electrical reactions.

The results of the operation depend to a great extent upon the interval that has elapsed between the time of injury and the operation. The greatest number of recoveries or instances of improvement after neurolysis occurs in cases operated upon within five months after the injury. Eighty to 100 per cent. of the cases in which this operation is indicated, recover or improve when the operation is performed within the period just mentioned. Only 30 to 75 per cent. recover when

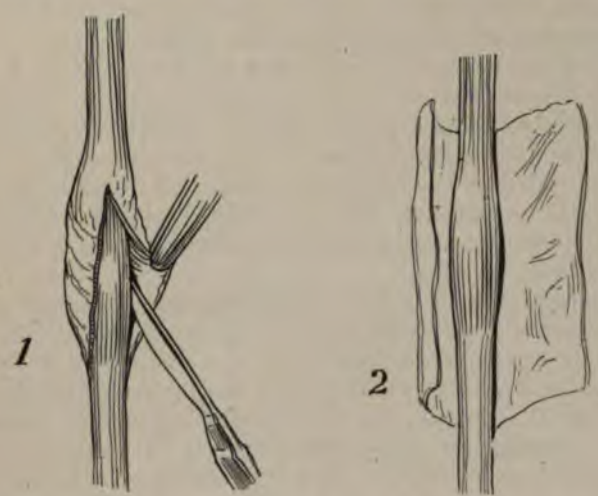

FIG. 272.—*1*, capsulectomy followed by use of Cargile membrane for neurolysis.

the operation is delayed eight and a half or nine months, and the fewest recoveries occur in patients operated upon later than this. Neurolysis should, we believe, be resorted to early, in cases in which there is no evidence of return or only partial return of function after injury. The exposure of the nerve permits of an accurate diagnosis, and the pathological condition can be corrected. The early operation increases the number of recoveries and prevents the atrophies and contractures which may develop as the result of loss of function.

The value of *endoneurolysis* is somewhat doubtful, for the changes which occur within the nerve after the operation may interfere or prevent the return of function. Parallel epineural incisions may suffice in such instances to permit the downgrowth of developing neurofibrillæ through the injured portion of the nerve. It has been advised in some cases to inject, as advocated by Hoffmeister, novocain into

the nerve to separate the scar tissue and favor the downgrowth of neurofibrillæ.

When exposing the injured nerve the dissection should be made whenever possible along intermuscular septa in order to prevent hemorrhage and to avoid the cutting of muscle fibers. The oozing which occurs from cut muscle fibers favors the development of adhesions about the nerve, if it is placed in contact with the cut surface. Adhesions even if few and delicate may seriously interfered with the function of the nerve.

Uninjured neighboring muscles form the best bed for a liberated nerve and should be used whenever possible. Usually a muscle can be secured for this purpose, but it may have to be displaced somewhat.

In many instances, however, in which this operation is indicated a great amount of scar tissue is found and some method other than that just mentioned must be resorted to, to prevent the reformation of scar tissue and of adhesions about the liberated nerve. Various materials such as decalcified bone tubules, silk protective, hardened bloodvessels, human epidermis, magnesium tubules, hardened gelatin tubules, Cargile membrane, fascia, fat, etc., have been used to surround the liberated nerve with the view of preventing the formation of scar tissue. Most of these have been discarded. Cargile membrane, fat and fascial transplants, free or pedunculated, and bloodvessels hardened in formalin, are used most frequently for this purpose at the present time.

Fat transplants, free or pedunculated, have been used rather extensively to surround a liberated nerve or a suture line. Rehn stated, as a result of his experimental work, that fat when transplanted remained as fat, and that while some of the fat might be discharged as oil through the wound, that the fat which remained regenerated fat. From observations made during operations which I have performed upon nerves which have been surrounded by a fat transplant, I have come to the conclusion that fat disappears and is replaced by adhesions, which though they may be thin and delicate may seriously interfere with the function of a nerve. Whether such a transplant interferes with the vascularization of the nerve, cannot be stated with certainty, but I do not believe that the vascularization would be seriously interfered with unless long stretches of the nerve were surrounded by fat. In cases in which the muscles have been extensively destroyed and the scar tissue is great in amount, fat may be used for this purpose. But neurolysis by fat transplants is, I believe, inferior to muscle neurolysis.

Fascia has a very limited use in neurolysis. When a fascial transplant is placed in contact with scar tissue, it is apt to become transformed into a scar tissue and cause compression of the nerve. I have used successfully a fascial transplant in one case of musculospiral suture to surround the suture line, but in this instance there was a very small amount of scar tissue. The transplant in this instance

caused no compression, for there has been a complete recovery of function.

Cargile membrane comes in various thicknesses. The thinner varieties should be used for neurolysis. In instances in which a secondary operation has been performed after the thicker varieties have been used, the membrane has been found in the tissues acting as a foreign body. The thinner varieties are apparently absorbed in six months or less. During this time the membrane has served its purpose in protecting the liberated nerve from compression by scar tissue. Cone believes that Cargile membrane prevents the straying of neurofibrillæ into the surrounding tissues.

Calves' arteries hardened in formalin (Foramitti's method) were used rather extensively after the Russo-Japanese War. Hashimoto used these when performing neurolysis. His results were good. The method is, however, not used to any extent at the present time.

Liberation of the nerve must often be combined with removal of the thickened epineurium and the scar tissue adherent to it. Parallel incision of the thickened epineurium overlying an indurated thickening of the nerve is often required.

Neurolysis is of distinct value in cases of physiologic interruption of a nerve with or without degeneration in the segment distal to the point of injury. It may be used to advantage when the chief symptom is pain and in causalgia. Its value in causalgia will be discussed later. Muscle neurolysis is to be preferred. Cargile membrane is to be preferred to fat transplantation, when muscle cannot be used.

Nerve Suture — Neurorrhaphy. — Nerve suture is required when there has occurred a solution of continuity—partial or complete—of a nerve. If the nerve is sutured immediately or within a short while after it is divided, the operation is referred to as primary nerve suture. When the suture is performed some time after division it is referred to as secondary nerve suture. If there has been an actual loss of nerve substance, it may be impossible to perform an end-to-end suture and some of the methods, which will be described later, may have to be resorted to.

Primary Nerve Suture.—Primary nerve suture is required for the repair of nerves accidentally cut during operations, *e. g.*, the spinal accessory in removal of glands of the neck, and for the repair of nerves severed by missiles, cutting instruments, or following subcutaneous lacerations, *e. g.*, in fractures, or by overstretching. Primary suture should be attempted in almost all instances after nerves are divided.

Suppuration will prevent the repair of a nerve after suture and because of fear of infection, primary suture is frequently not attempted. Even if infection does occur after primary suture nothing has been lost, for secondary suture can still be attempted and besides the sutures inserted at the primary operation will probably keep the ends of the segments in line and they can be more readily found at the second operation.

In performing primary suture the contused or injured parts of the

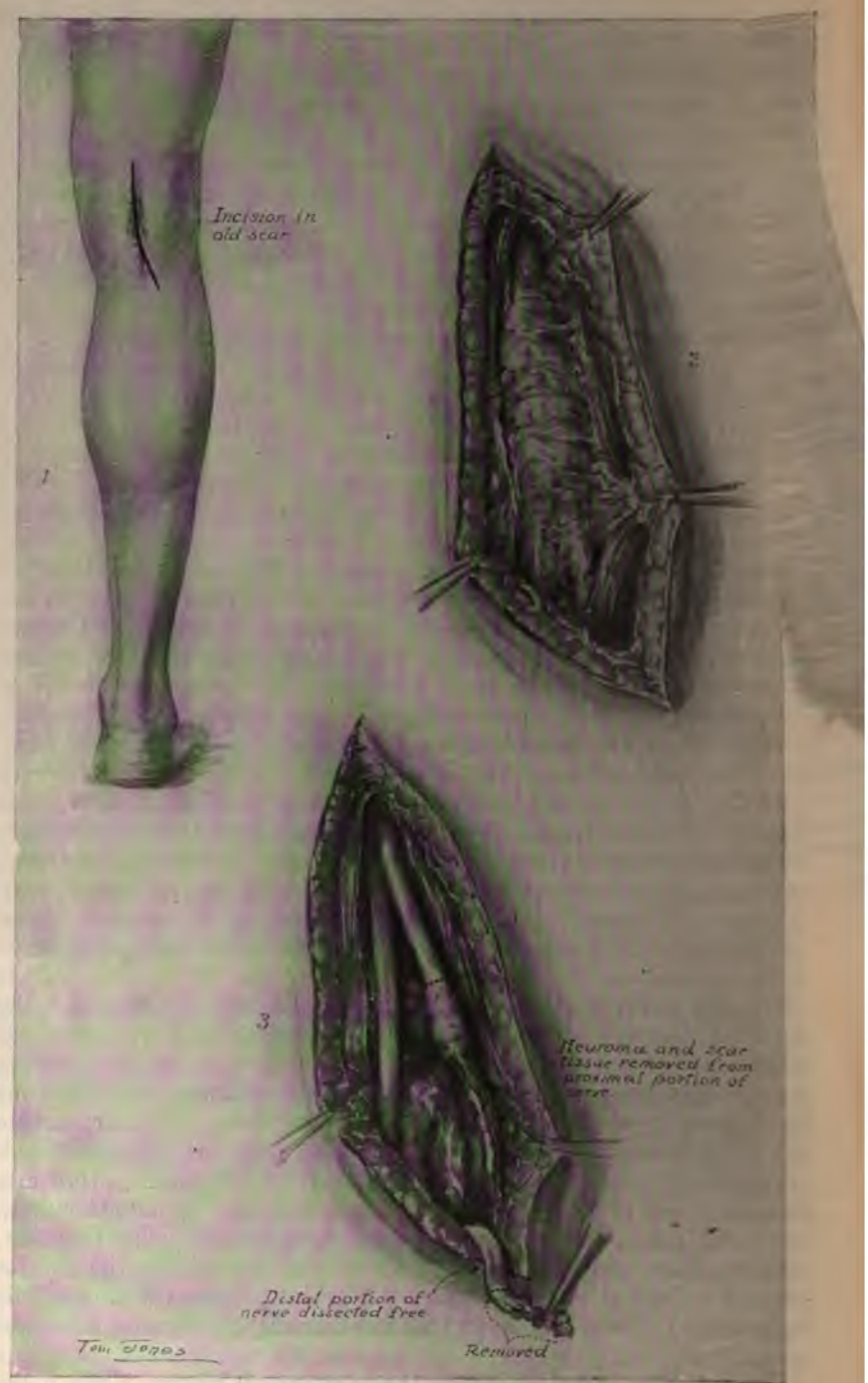
Incision in old scar
1
2
3
Neuroma and scar tissue removed from proximal portion of nerve
Distal portion of nerve dissected free
Removed

FIG. 273, *A*

nerve adjacent to the point of injury should be resected until healthy funiculi are exposed. When the wound is an incised one and fairly clean, but little of the ends will have to be resected. When the division is caused by a missile—bullet or fragment of high explosive—

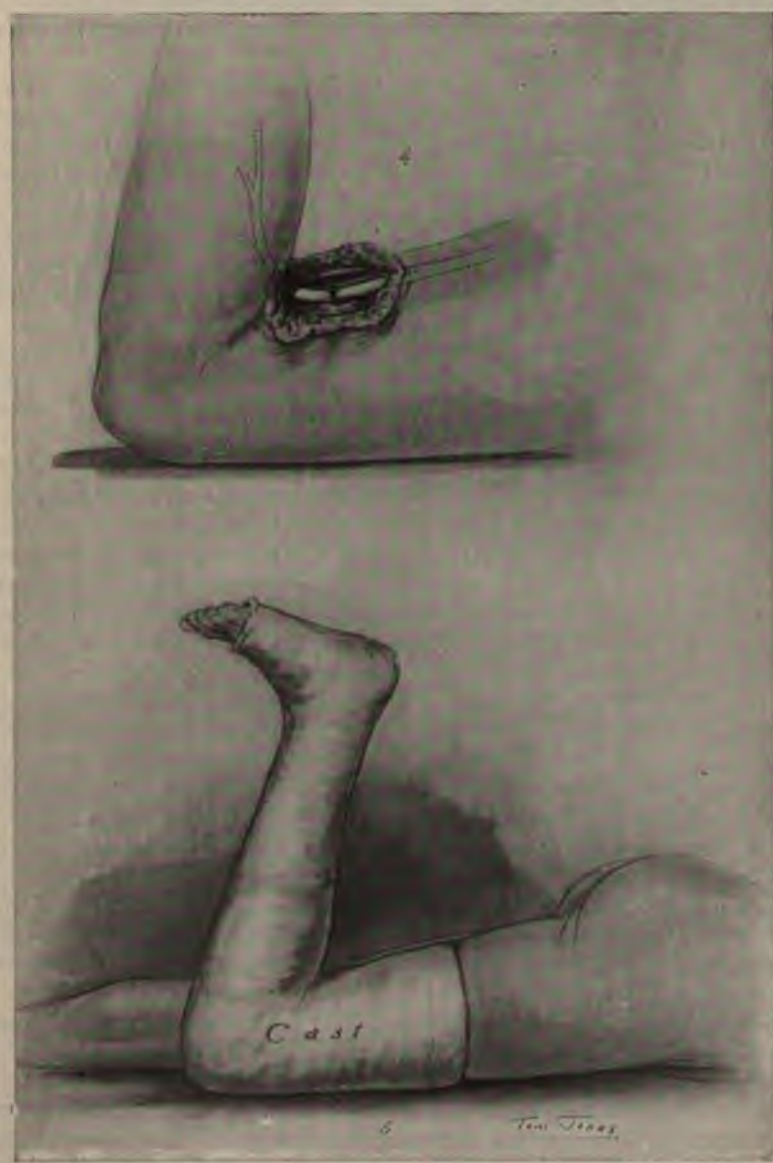

FIG. 273, *B*

FIG. 273.—Incision for exposure of external popliteal nerve and pathology following injury by a missile—end-to-end union by epineural suture and cast fixation. (Lewis, Surgical Clinics of Chicago, August, 1919, No. 4, iii, 776.)

the nerve is softened, or fused and infiltrated with blood for some distance on either side of the point of division. The softened and infiltrated portion of the nerve must be resected until healthy funiculi herniate before the suture is attempted, otherwise a spindle-shaped enlargement of the nerve due to scar tissue will form which may be impermeable to the developing neuraxes. Neurotization of the distal segment may be prevented by such a scar.

Fine (No. 000 chromic) catgut is to be preferred for primary nerve suture. The ends of the nerve may be united by epineural sutures or these may be combined with two transfixion sutures. Transfixion sutures are regarded by many as essential in order to avoid a dead space in the center of the nerve which may fill with a blood clot which will favor the development of a scar, thus preventing the developing neuraxes from penetrating the distal segment. If epineural sutures alone are correctly and accurately applied no dead space will be left when the ends of the nerve are approximated.

It is very essential in performing nerve suture to close the epineurium. If the epineurium is accurately closed there will be no straying of the neurofibrillæ into the surrounding tissues and the amount of scar at the point of suture will be greatly reduced.

As accurate anatomical repair as possible should be made. There is some dispute concerning Stoffel's work upon the internal topography of the peripheral nerves. The position of the different funiculi may vary in different nerves and at different parts of the same nerve. Even if Stoffel's work should prove to be incorrect, he has done a good service for peripheral nerve surgery in emphasizing the desirability of accurate anatomical union, which should be insisted upon in all types of reconstructive surgery.

The sutures when tied should merely coapt the ends of the nerve. The ends should not be crushed together and all tension should be avoided. Even when primary suture is attempted it is often impossible to approximate the ends of the nerve unless the segments are mobilized or the extremity placed in a position which relaxes them. It is advisable to immobilize the parts during the first days after suture. When it is necessary the part should be fixed in flexion or extension in order to prevent tension upon the suture line. When this is required immobilization should be maintained for some time—in case of the median and ulnar nerves four to six weeks; in case of the sciatic six to eight weeks.

When secondary suture is attempted pathological conditions are usually found which render certain operative procedures necessary. During the process of healing scar tissue forms. This varies in amount depending upon the character of the wound. A small amount of scar tissue will be found in incised wounds which have healed without suppuration. In contused and gunshot wounds, especially those caused by high explosives, a fairly large amount of scar tissue will be found, especially if infection has occurred.

A neuroma, composed of growing neuraxes and scar tissue, will

usually be found upon the distal end of the proximal segment. A neuroma forms in practically all cases after nerve division. The proximal end of the distal segment will be capped or infiltrated with scar tissue.

In exposing the nerve segments, it is advisable to begin the dissection at some distance from the scar or site of the injuries. The

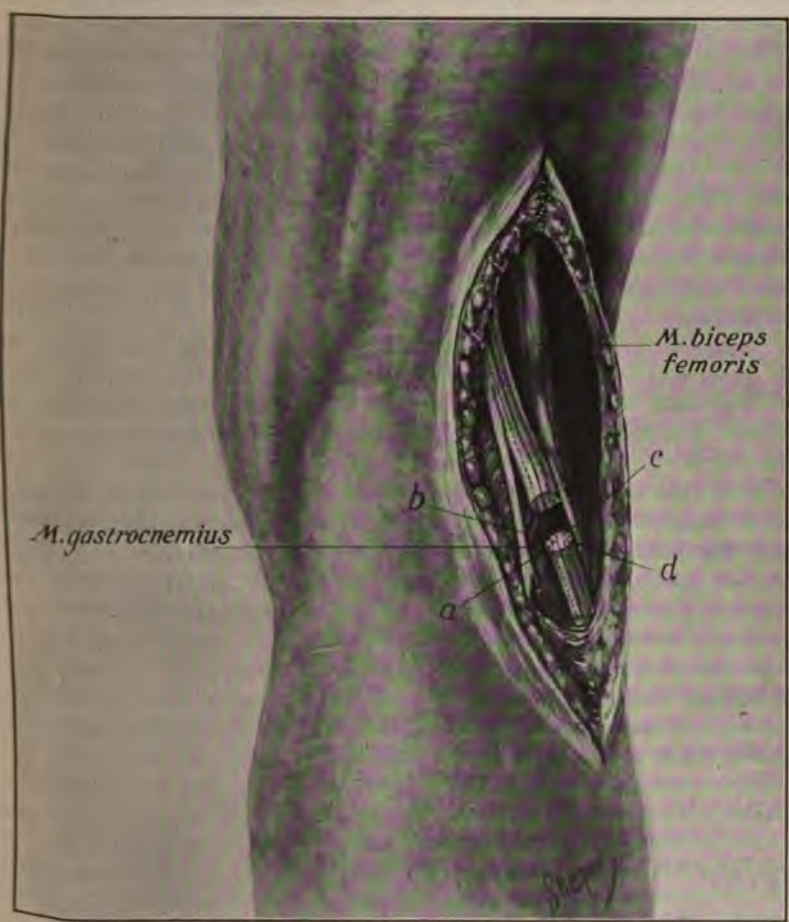

FIG. 274.—The distribution of funiculi in the external popliteal. The internal topography of Stoffel. The necessity of accurate anatomic repair is indicated by this arrangement.

nerves are exposed where normal anatomical relations have not been disturbed and they are then dissected out to the point of division. Traumatism of the nerve is avoided in this way and the operation is considerably shortened.

Before the nerve is entirely dissected out of its bed, two fine silk sutures or two small mosquito forceps should be placed upon either side of the nerves in order that axial rotation of the nerve trunks may

be avoided. As has been remarked before, there has been some criticism of late of Stoffel's work upon the internal topography of peripheral nerves. Stoffel's work may be questioned, but the principle of non-axial rotation of nerves during suture which he emphasized should be followed, and as accurate anatomical repair as possible should be secured. The surgeon who is most careful in performing an accurate end-to-end suture without axial rotation of the nerve segments will have the greatest number of successes.

The neuroma and scar tissue of the ends of the divided nerve should not be resected at once, for traction, if necessary, should be exerted upon this tissue in order to avoid traumatism of the nerve trunk. In some cases it is advisable when an end-to-end approximation cannot be secured to bring the two ends as closely together as possible with fairly heavy sutures by flexion or extension of the extremity as the case may be and after closure of the wound to gradually restore the part to its normal position, thus stretching the nerve segments. Later an end-to-end suture may be performed, if this procedure is successful.

Whenever possible an end-to-end suture should be performed. In many cases the nerve ends cannot be easily approximated and it may be necessary to mobilize the nerve; to displace it and to place the extremity in positions which permit of approximation of the ends of the nerve.

There has been some hesitancy about mobilizing nerves, for some have thought that subsequent repair might be seriously interfered with if a nerve were dissected out of a bed which provided its vascular supply. A long stretch of a nerve may be dissected out of its bed without apparently interfering in the least with the reparative process. In operating upon the sciatic it may be necessary to free the nerve well down into the popliteal fossa, and to separate it from its bed as high as the sacrosciatic notch. When the nerve is so mobilized, it may be possible when the knee is flexed to perform an end-to-end suture, even when there has been a considerable defect.

Posture must be frequently resorted to. It may be necessary to displace the nerve trunks, *e. g.*, the ulnar nerve can be dissected out of the groove behind the internal condyle and displaced anteriorly. Considerable distance can be gained in this way when the forearm is flexed. In case of musculospiral division, it may be necessary to displace the distal segment to the inner side of the arm beneath the biceps.

After the operative procedures which are required to secure an end-to-end suture have been resorted to and it is found that the ends can be approximated, the neuroma and scar tissue should be resected. The resection should be made with a sharp instrument. A Gillette safety blade grasped in an artery forceps answers the purpose very well. Thin pieces of the nerve should be carefully removed until healthy funiculi herniate from the cut end of the nerve.

The removal of scar tissue is essential. Many of the failures of

nerve suture have been due to the unwillingness of the operator to resect enough of the ends to expose healthy funiculi. Undoubtedly neurofibrillæ may penetrate scar tissue, but, as a rule, it forms a block for developing neurofibrillæ and interferes with nerve repair. There has been a tendency of late to revive *the suture by neuroma.* This is bad practice and should be discouraged. An effort should always be made to make the suture in healthy nerve tissue.

In performing secondary suture the same principles apply as in primary. The neuroma and scar tissue complicate secondary operations. They require, as has just been stated, special attention.

In the after-treatment immobilization should be maintained where changes of position have been necessary for an end-to-end suture for different lengths of time, depending upon the size of the nerve. In case of the sciatic, when the knee is flexed immobilization should be maintained for from six to eight weeks; in case of the ulnar and median about four, in some cases six weeks. In one case of sciatic suture, where the defect measure 7.5 cm., I extended the leg gradually after it had been flexed four weeks without doing any damage to the suture line. This patient had decided evidences of recovery at the end of seven months.

Fine silk or No. 000 chromic catgut may be used in suturing the nerve. Small, round intestinal needles, straight or curved, should be used. Gentle manipulation, a small fine-toothed forceps being used for grasping the nerve, is an absolute essential. One or two transfixion sutures depending upon the size of the nerve may be inserted first. Two will usually suffice even in the larger nerves, *e. g.*, the sciatic. These should be inserted not less than half an inch from the cut end. While these sutures are being inserted and tied the part should be placed in the position in which it will be fixed when the operation is completed. The coaptation sutures are next applied through the epineurium. These may be interrupted or continuous. When interrupted enough should be inserted to close the epineurium in order to prevent the straying of neurofibrillæ.

While the type of suture just described is preferred by many operators, I believe that four to six sutures passed through the epineurium will usually suffice to accurately approximate the ends of the nerve. Fine silk or catgut may be used. The objection which has been raised against this type of suture is that the funiculi in the center of the nerve ends retract and that a dead space which fills with a blood clot forms. If the epineural sutures are applied correctly, accurate approximation can be secured. It is essential that the epineurium be closed. The results following these two types of suture do not differ.

The suture line should be protected from scar tissue. Uncut muscle fiber, as stated under neurolysis, forms the best protection. If healthy muscle cannot be used, it may be necessary to surround the suture line with fat or Cargile membrane.

If there has been an actual loss of substance and an end-to-end

suture cannot be performed after the procedures just described have been attempted, some one of the methods about to be described must be resorted to.

Experimental work would seem to show that spontaneous regeneration may occur across a gap in a nerve without the use of any artificial aid to conduct the developing neuraxes, provided that the distance between the ends does not exceed three-quarters of an inch in length. Spontaneous regeneration with bridging of defects does undoubtedly occur in animals. It is doubtful whether it ever takes place in man, although some cases have been reported in which it has apparently occurred. When, therefore, a gap exists in a nerve some attempt should be made to unite the ends artificially, for this furnishes the only chance for anatomic repair with subsequent reëstablishment of function.

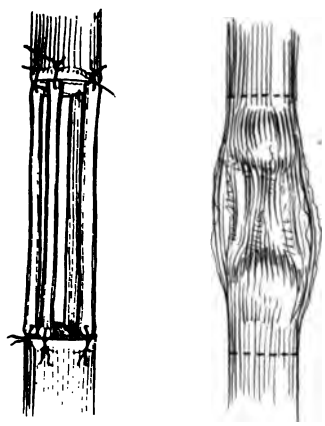

FIG. 275.—Auto-cable transplant.

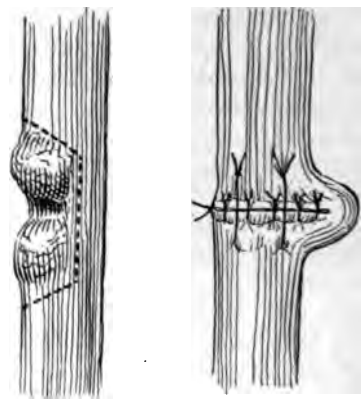

FIG. 276.—Illustrates method of repair of incomplete division of a nerve. Excision of scar followed by suture without sacrificing intact funiculi.

In attempting to bridge a gap, nerve-grafting, nerve transplantation (auto, homo, hetero), fresh or preserved, and tubulization have been resorted to. None of these have given constant results and they are only to be resorted to when all attempts at an end-to-end suture have been unsuccessful.

Nerve Grafting.—In this operation, the nerve which has suffered the loss of substance, is grafted upon a neighboring nerve. In the arm and forearm, *e. g.*, the upper end of the ulnar may be grafted into the side of the median and the distal end of the ulnar may be grafted into the corresponding part of the median at a lower level, an attempt being made to tap the funiculus with which the lower end of the upper segment has been united. This operation is practically an auto-transplantation, the transplant not being raised from its bed. Whenever possible, the sensory part of the nerve should be

used to conduct the fibers. When sensory bundles cannot be used for this purpose, funiculi which can be sacrificed without increasing the already existing disability should be employed. Extensive multiple nerve grafting has been advocated by some, notably Hofmeister, but the final results evidently do not justify the enthusiasm of the early reports. The results which have been obtained in anastomosis of the hypoglossal or spinal accessory indicate the possibilities of nerve grafting when carefully performed.

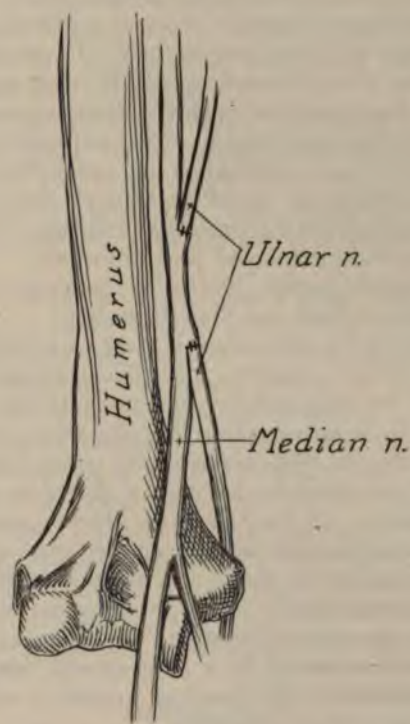

FIG. 277.—Illustrates method of nerve grafting.

Flap operations, such as the one described by Lètiévant, are not to be recommended. Experimental work indicates that successful repair does not follow the use of this method. A few successes after its use have, however, been reported, but in these cases the possibility of the misinterpretation of supplementary movements must be taken into consideration.

Nerve Transplantation.—Nerve transplantation has been more or less extensively resorted to from time to time during the past few years to bridge defects in nerves. Experimentally it has been demonstrated that a segment of a nerve transplanted into a defect in another nerve will conduct neurofibrillæ into the distal segment of the injured nerve with complete regeneration of motor end plates and the restoration of function. Huber has studied this subject exhaustively.

He advises the use of the auto-cable transplants. In this operation a cutaneous nerve which can be spared, such as the internal cutaneous, the superficial branch of the radial, the external cutaneous of the thigh, or the short saphenous is removed and divided into three or four pieces. These form the cables, uniting the ends of the divided nerve. The total diameter of the transplanted pieces should approximate as nearly as possible the diameter of the ends of the nerve to which they are sutured. Auto-transplantation is to be preferred. Homo-transplantation is, however, successful. When heterotransplants are used, the transplanted portion of nerve evidently dies for it takes a heavy black stain with the silver method. In animals the developing neurofibrillæ when the heterotransplant is used grow down on the outer side of the transplant to reach the distal segment.

Transplants may be preserved in liquid petrolatum or sterile vaseline and still serve as a scaffolding or conductor of neurofibrillæ. Nageotte has advocated the use of fetal calves' sciatic nerve hardened in 50 per cent. alcohol for the bridging of defects. This method has been rather extensively employed by the French. No reports which have been published justify, however, the enthusiasm which was aroused when this method was first suggested.

The results obtained in experimental work cannot apparently always be obtained in clinical surgery, for while experimentally complete regeneration can be obtained by the methods just described, it is often impossible to secure results clinically when these methods are employed. Sherren, in 1906, reported 30 cases in which a segment of a nerve had been transplanted into a defect in another nerve to restore its continuity. Of the 8 cases in which a segment of a human nerve had been transplanted, but 3 were reported at sufficient intervals after the operation to admit of a possibility of recovery. Two of these recovered completely and 1 presented no evidences of return of function after seventeen months. Of 22 cases of hetero-transplantation, 16 were reported at a long enough period to have permitted of some recovery. Of these but 1 could be said to have recovered definitely and without question.

A number of auto-transplants have been used in the repair of defects in those wounded in the recent war. Not enough time has elapsed to permit of any opinion concerning the results. In some there has undoubtedly been some return of function, which is quite limited, and the transplant has increased considerably in size. The block to developing neurofibrillæ may occur at the point of union between the transplant and the proximal end of the distal segment for scar tissue may form at this point before the neurofibrillæ reach it. If after a reasonable length of time there is no return of function, it may be indicated to expose the transplant at this point. The operative procedure then to be followed will depend upon the gross findings and the electrical reactions.

Tubulization. — Experimentally neurofibrillæ will bridge a gap when a tunnel is formed through which they can grow. Decalcified

bone tubules, a segment of a vein or artery, fascia and a number of other materials have been used to connect the two ends of a nerve and to form a pathway for developing nerve fibers. While complete regeneration of a nerve even to the formation of myelin sheaths occurs in animals after tubulization, there are not enough favorable results reported in clinical surgery to justify its use, except as a last resort when other procedures cannot be employed with much hope of success.

Platt has had a relatively extensive clinical experience with this method. His results clinically differ entirely from those obtained by Kirk and Lewis in their experimental work upon fascial tubulization. Platt's conclusions are as follows:

1. In 18 operations in which fascial tubulization combined with autogenous nerve grafts, fascial tubulization alone, and autogenous vein tubulization (1 case), were used, there was a complete absence of any clinical signs of recovery. The shortest period over which observations were made was four months, the longest period twenty-six months.

2. Secondary exploration in 4 cases showed complete silence of the nerve trunk to direct faradic stimulation. End-to-end suture was accomplished in all after exsection of the bridged segment.

3. At the reëxploration operations, partial or complete obliteration of the lumen of the fascial tube was noted.

4. In two specimens examined histologically, one, a tubulization alone, showed obliteration of the lumen of the tube by fibrous tissue in which no nerve fibers could be found. In the second, a graft and tubulization combined, nerve fibers were present in the center of the obliterated tubule eighteen months after the operation. There was no sign of continuity between the proximal and distal ends through this strand of nerve fibers.

5. The early reëxploration of all graft and fascial-bridge operations is advisable.

CAUSALGIA.

Causalgia is a clinical syndrome characterized by a burning pain of the part involved. This burning pain is associated with trophic disturbances. Maceration and ulceration may follow the continued use of cold water employed to relieve or control the pain. Causalgia most frequently follows gunshot wounds or injuries of the median and internal popliteal nerves. The pathology varies. In some cases the nerve is injected and larger than normal and evidently inflamed, while in other cases it may be indurated or bound down in a scar. Joyce observed one case in which a piece of high explosive was treated by roentgen-ray examination in the neighborhood of the sciatic nerve. The piece of high explosive was found near the nerve but not in contact with it when the operation was performed. Relief from the causalgia followed removal of this fragment. Causalgia tends to recover spontaneously.

Causalgia may be successfully controlled or cured by the injection of 60 per cent. alcohol directly into the nerve involved. This method was first suggested by Sicard. The nerve should be exposed above the site of the injury and 2 to 3 c.c. of 60 per cent. alcohol injected into it. The injection gives almost immediate relief with but little tendency to recurrence. It is to be preferred, I believe to peri-arterial sympathectomy advised by Leriche. When neurolysis is employed in these cases, it should be combined with alcohol injection, for neurolysis alone is not often successful.

FIG. 278.—Injection of 60 per cent. alcohol into the nerve to cure causalgia following injury and cicatricial compression. (Lewis, Surgical Clinics of Chicago, August, 1919 No. 4, vol. iii.)

RECOVERY AFTER SUTURE.

When a peripheral nerve has been divided recovery of function of the muscles supplied by it takes place slowly, even when primary suture has been performed and all the principles of neurosurgery have been closely followed. Dr. Lewis has observed return of motor function in two cases of suture of the musculospiral nerve after five and one-half months.

The paralyzed muscles should receive careful attention after a nerve is divided and during the period of repair following suture. Stretching of the paralyzed muscles should be guarded against. Overstretching of the muscle fibers prevents or interferes with the return of tone and prolongs disability. Splinting should be of the elastic rather than of the rigid type. Rigid splinting, often in an overcorrected position, is frequently followed by fibrous ankylosis of the joints and marked atrophy of the affected muscles. In many cases which we have recently seen, it has seemed as if the amount of atrophy was almost directly proportional to the care and assiduity with which the splinting had been done.

During the after-treatment there should be the closest coöperation between the surgeon, neurologist and physiotherapist. Each case should be studied repeatedly and the treatment modified from time to time, depending upon the conditions found at the time the examination is made.

Fibrosis of the joints, especially of the metacarpophalangeal and intermetacarpal in the hands, must be carefully guarded against.

Success in peripheral nerve surgery is dependent upon careful dissection, avoidance of injury or contusion of the nerve, asepsis, the control of hemorrhage and perfect anatomical repair. An end-to-end suture gives the greatest percentage of recoveries. When an end-to-end suture cannot be performed, one of the other operations described above must be resorted to.

Recovery occurs most rapidly after suture of the musculospiral—as stated before, return of function has been noted by us within five and a half months after suture. The median and ulnar are next in order as regards length of time for recovery after suture. This statement applies to the larger muscles supplied by these nerves. The muscles controlling the finer movements of the hand recover more slowly. The internal popliteal portion of the sciatic recovers fairly rapidly after suture. It has been our experience that the external popliteal nerve recovers slowly after suture. We have observed one case in which there was definite return of function within six months after suture of the external popliteal nerve. Most of the cases of suture of this nerve, however, have shown the first evidences of recovery relatively late, as late as sixteen or eighteen months.

The loss of epicritic sense is noted long after recovery of motor function and in many instances in which there has been almost perfect return of motor function, there has been some disability owing to the loss of epicritic sensation.

PERIPHERAL NERVE INJURIES. CLINICAL CONSIDERATIONS.

Incidence.—In the casualties of the late war, injuries to the peripheral nerves comprised a formidable group. At one time 333 cases of injury to the peripheral nerves were found in a personal bed-to-bed canvass of 5050 patients in Base Hospitals in France. Of these 2130 had wounds in their extremities.

In Dr. Pollock's experience peripheral nerve lesions occurred in from 4½ to 5 per cent. of the total casualties and in 15 to 16 per cent. of the cases wounded in their extremities.

Statistics relating to the incidence of peripheral nerve lesions have only a relative value depending as they do upon the intensity with which a search for such lesions had been made in the various hospital centers.

Statistics relative to the specific nerves affected depend for their accuracy upon a number of factors, included among which is the terminology employed. The absence of a standard anatomical terminology and the fact that some nerve lesions escape notice because of the absence of prominent clinical signs, for example, internal popliteal injuries, is responsible for inaccurate tabulations.

Of equally great importance is the period of time following the injury when the tabulation is made. Many injuries have a tendency to rapidly recover spontaneously. Notable among the cases were brachial plexus injuries, of which twice the number found in a general hospital in the United States were found among a similar number of cases in Base Hospitals in France. Of a similar character were lesions of the internal popliteal, posterior tibial, anterior crural and circumflex nerves.

Of 1020 cases of injuries of the peripheral nerves, 987 accessible records showed the most frequent injuries to have occurred in the following nerves in the order in which they are named: musculospiral, including lesions of the posterior interosseus, 165; sciatic, 160; ulnar, 136; external popliteal, 120; median, 93; brachial plexus 71, and combined ulnar and median, 58.

TABLE I.

Ulnar	136
Median	93
Ulnar and median	58
Musculospiral	100
Radial	65
Radial and median	12
Radial and ulnar	13
Musculocutaneous	4
Ulnar, median and musculocutaneous	3
Ulnar, median and radial	6
Circumflex	7
Brachial plexus	71
Sciatic	160
Sciatic (E. P. Branch)	11
Sciatic (I. P. branch)	2
External popliteal	120
Internal popliteal	25
Posterior tibial	12
Anterior tibial	16
Lumbar plexus	4
Sciatic and small sciatic	9
Anterior crural	19
External saphenous	16
Musculocutaneous	8
Long thoracic	2
Internal saphenous	1
External cutaneous	3
Causalgia	5
Minor nerves	6
Total	987

Examination, Motion and Sensation.—Signs of Injury.—To profitably study the signs of peripheral nerve injury and degeneration, it is necessary to have standard methods of examination.

The most evident consequences of an injury to a mixed nerve is paralysis. If it were possible to isolate each muscle and observe its action upon volition, the examination of the motor function would be simple. Unfortunately, this is not the case and we are compelled to observe the action of such muscles through the movements of segments about a joint which they inaugurate.

The frequency with which more than one muscle may produce a similar movement of the segments about a joint emphasizes the necessity for the use of great care in the analysis of all muscle movements. This care is the more necessary because the muscles under consideration may receive their nerve supply from different sources. The preservation of certain movements whose loss is supposed to follow particular nerve lesions has been observed for many years. These movements may be caused by a number of factors. Among these may be included the anastomotic supply of muscles from adjacent nerves, movements produced by muscles other than primary movers in this action, movements occurring as the result of mechanical factors producing a change of direction of leverage, by shortening and lengthening the tendons and muscles passing over several joints, and slight movements resulting from the recoil of elastic tissue following a movement in a direction opposite to the one desired.

It is to the misinterpretation of such movements that miraculously rapid recoveries following resection and suture of peripheral nerves by some surgeons, must be attributed.

The extent of the influence of supplementary movements can be demonstrated by dynamometric examination of the various segments of an extremity. For this purpose Dr. Pollock has found the spring scales method simple and efficient. By interposing a spring scales between the examiner's hand and the segment to be examined, the strength of any movement may be readily determined. It is necessary, of course, to exercise care in preventing the movements of segments other than the one being examined to contribute to the reading. This is notably true in examining the strength of the lumbricales in flexion of the proximal phalanges of the fingers (Fig. 279).

For many years it has been noted that total loss of sensation after complete division of a peripheral nerve is limited to a much smaller area than we would expect from its anatomical distribution. Likewise, it has been observed that following injury of a peripheral nerve, sensory symptoms may rapidly diminish and at times loss of sensation to pin-prick be entirely absent. That severe, widespread anesthesia results only from trauma of several nerve trunks of a plexus, had been generally accepted. Lesions of single nerves result in partial anesthesia, or if a severe anesthesia be present the area of complete loss of sensation rapidly shrinks.

Many attempts have been made to explain these phenomena. The

brilliant studies of Head, Rivers and Sherrin have resulted in a theory of the physiology of sensation which has almost generally been accepted. Whereas previous observers have stated that sensation is diminished over the full area usually assigned to the injured nerve and lost completely over a small portion only, they have shown that this diminution of sensation is in reality a total loss of so-called epicritic sensibility; that is, to stimulation with cotton-wool, to degrees of temperature between 22° and 40° C., etc. The only sensation preserved is the so-called protopathic sensibility; that is, pain to prick of a pin and temperature below 20° C. and above 40° C.

From a study of 500 cases of peripheral nerve lesions observed soon after injury, Dr. Pollock has seen that in many cases for the first two or three weeks, only a very small area within the border of the part insensitive to cotton-wool was sensitive to pin-prick; that in a few a larger zone

FIG. 279.—Dynamometric examination of pronator radii teres.

sensitive to pin-prick appeared within fifteen days, and that the return of sensitiveness to pin-prick in a larger zone, corresponding to the area which was later determined as nerve overlap, was found at times variable from thirty to one hundred days.

It is essential to determine the cause of this relatively early return of prick-pain. We must define that return of sensation which is due to the regeneration of a nerve and that which is due to the assumption of function of adjacent and overlapping nerves.

It is to the misinterpretation of this early return of a prick-pain that many early "recoveries" following nerve suture have been attributed.

He maintains that the return of sensibility to prick-pain which occurs before the return of sensibility to touch, is due to the assumption of function by adjacent nerves. This return of prick-pain always appears in similar areas in individual nerves and occupies the zone of nerve overlap. This zone may be determined by noting the residual sensa-

tion of a nerve. For example, if we wish to determine the residual sensibility of the radial nerve, we sever all the adjacent nerves, ulnar, medial and musculocutaneous; the area of skin in which sensation is preserved is the total sensory supply of the radial (Fig. 280). That portion of this skin which extends beyond the recognized anatomical distribution of the radial nerve is the area of the overlap of the radial nerve to its adjacent nerves.

FIG. 280.—Residual sensibility to prick-pain of the musculospiral nerve following section of the ulnar, median and musculocutaneous nerves.

It is necessary, if one uses ordinary clinical methods of examination, that is, a pin for determining presence of pain sense, to know the area in which the return of prick-pain should not be employed as an indication of nerve regeneration.

Now, if low degrees of pressure be employed; that is, 10 grams, it will be found that the area of analgesia closely follows the loss of touch sense. If such a method be used, areas of overlap need not, for clinical purposes, be remembered.

In the examination for sensation to touch it must be remembered that whether wisps of cotton be used or hairs employed, the pressure must be less than would produce the sense of pressure which is subserved by deep sensibility. All hairy surfaces must be closely shaven when an accurate border of loss to touch is desired.

Pain sense should be studied by means of algesiometers so that a known degree of pressure be employed. If unknown and great degrees of pressure be used, as in the employment of a pin, areas of nerve overlap must be recognized.

Clinically, temperature sense must be examined by relatively inaccu-

rate methods, such as test-tubes containing water of a known tempera-
ture, or, preferably, metallic cylinders which may be heated or chilled.
Dr. Pollock has found that for a relatively low temperature, a pledget
of cotton twisted to a point and moistened with ether produces a stim-
ulus which may be used rapidly and may be applied to a smaller area
than a test-tube.

Signs of Severe Lesions.—Many attempts have been made to discover
a sign or groups of signs which would justify a rapid differential diag-
nosis between a case having a complete anatomical section of a nerve
and one in which complete loss of function is not the result of division
of the nerve. Similarly, attempts have been made to differentiate
those cases having complete loss of function which are spontaneously
recoverable, from those which are not and which require surgical
interference.

At one time it was thought possible to distinguish several definite
symptom-complexes. Prominent among these were the groups adopted
by Mme. Déjerine and J. Mouzon. They defined the syndromes
of interruption, of compression, of irritation, of dissociation and
recovery, each having a distinctive group of symptoms.

Unfortunately, it was proved by subsequent observations by others
that this classification was artificial and unreliable for the purpose of
certain diagnoses.

To our knowledge there is no way by which the complete loss of
function due to anatomical interruption can be differentiated from the
complete loss of function due to physiological interruption produced
by compression, etc. From a single examination, at a given time, we
can only determine whether the lesion is complete or incomplete. If it
is complete we cannot tell whether it be due to anatomical interruption
or not, nor can we predicate whether it will spontaneously recover or
require surgical treatment. Of course, if it is incomplete, anatomical
division cannot be present except in the form of a lateral notch.

In a case of complete physiological interruption, only when a sub-
sequent examination shows some return of function, may we say that
the lesion is incomplete and an anatomical interruption absent. No
other sign or groups of signs suffice. In general, the course of the
clinical picture is much more important than any group of signs for
the purpose of determining the severity of a lesion.

The various clinical signs resulting from a complete interruption
of a nerve have been given a different value and significance by different
investigators. Each one has proposed a certain grouping of symptoms
in the order of their supposed value and many have added certain signs
of their own. Common to most may be found: (I) Complete paralysis
of all muscles supplied by the nerve below the lesion. (II) Complete
reaction of degeneration. (III) Rapid and extensive atrophy of the
paralyzed muscles. (IV) Absence of pain on pressure applied to the
nerve trunk below the lesion. (V) Loss of objective sensibility in the
supply of the affected nerve. Many include absence of tonicity with
characteristic attitudes of the limbs in repose, as wrist drop, foot drop,

etc., absence of any pain on pressure of the muscle supplied by the injured nerve, exaggerated excitability of the muscles to mechanical stimuli, abolition of corresponding reflexes, absence of any zone of hyperesthesia or paresthesia in the region supplied by the injured nerve, vasomotor and trophic disturbances.

We shall define the extent to which we believe the loss of such functions as we consider most important may be employed in determining the severity of a peripheral nerve lesion.

Complete loss of all the functions of a nerve indicate a severe lesion and is interpreted as a complete physiological interruption of that nerve.

Total paralysis of all the muscles supplied by a nerve distal to a lesion cannot alone be used as an indication of the severity of that lesion. Particularly is this true of the musculospiral nerve where slight injuries produce total paralysis. Only when sensation is present in the isolated supply of a nerve can the lesion be considered as a partial one. The area of the isolated supply to pin-prick of various nerves is the area in which no overlapping occurs.

Corresponding to the area of the isolated supply of a nerve to pin-prick is found analgesia to pinching, and in the writer's opinion is an excellent indication of a severe nerve lesion.

Regarding the electrical changes demonstrated by the methods personally employed, namely, Faradic and Galvanic stimulation, it may be said that complete reaction of degeneration is always present in a severe lesion but does not indicate an irreparable one. Of all the changes to electrical stimulation the slowness of the muscular contraction was the only constant phenomenon which could be satisfactorily employed in determining the reaction of degeneration. Polar changes were inconstant and, of course, it may be expected the response to Faradism would be absent frequently, even in partial lesions. Especially is this true of cases requiring more than four months for recovery. Although electrical examination afforded no means whereby a differentiation between anatomical and physiological interruption could be made in the cases observed within a year following injury, it must be remembered that frequently after this period and always after a hundred weeks, irreparable lesions show complete loss of response to any form of electrical stimulation.

The longitudinal reaction did not prove to be of any particular diagnostic or prognostic value. Of some interest was the fact that masses consisting of muscles supplied by nerves, severely, and often irreparably injured, showed great increase of resistance to the continuous current. The constancy of this phenomenon unfortunately could not be controlled and its real significance therefore was unascertained.

Rapid and extensive atrophy of the paralyzed muscles may be interpreted as meaning a severe lesion with a number of reservations. Ulnar nerve lesions as a rule show extensive atrophy whether severe or not. Atrophy is of service in denoting the severity of a lesion only

when seen soon after injury. The amount of atrophy observed some months after injury is not commensurate with the severity of the lesion.

Measuring the amount of atrophy in the upper extremities distal to the elbow and in the lower distal to the knee, by water displacement the following facts were found. As compared to the unaffected extremity the affected one showed in an irreparable ulnar nerve lesion an atrophy of 4.5 per cent. of the total mass, in recovering lesions 4.2 per cent.; in radial nerve lesions there was an atrophy of 4.3 per cent. in recovering lesions, 5 per cent. in irreparable ones. In lesions of the median nerve those recovering showed 11.2 per cent. and irrecoverable ones 15 per cent. atrophy; in sciatic nerve lesions recovering lesions showed 9.7 per cent. and those irrecoverable 10 per cent.; the external popliteal showed in the recovering lesions 6 per cent. and in the irrecoverable ones 7.2 (Fig. 281).

FIG. 281.—Can with spout for measuring atrophy by means of water displacement.

Although the percentage of loss of muscle mass was slightly greater in the severe, irrecoverable lesions, the difference was not sufficient to be of diagnostic value. In addition to this, some irrecoverable sciatic nerve lesions showed but 1 per cent. loss when a recovering one showed a 17 per cent. loss. In a recovering external popliteal nerve lesion we found 16 per cent. and in an irrecoverable one only 1 per cent. atrophy, etc.

In general it may be said that when observed some months after injury, absence of demonstrable atrophy is not an indication of a reparable lesion. It has impressed the writer that movement of the extremity, passive or active, is often responsible for an apparent lack of atrophy. How much any replacement of muscle by other tissue is responsible can only be conjectured.

Absence of pain when the trunk of the nerve is subjected to pressure

below the seat of the lesion was demonstrable in many severe lesions, but quite a number of recoverable lesions showed this analgesia as well. On the other hand, not a few irrecoverable lesions showed the preservation of pain to such pressure. Only the ulnar, musculospiral and external popliteal nerves are suitable for isolated pressure upon their trunks and this only in such cases where the injury is proximal to their superficial positions. The danger of producing pain by pressure upon adjacent structures is too great to make this a universally diagnostic phenomenon of certain value.

In agreement with Meige and Pitres, absence of any pain on pressure of the muscles which are paralyzed was found a very unreliable sign. In fact, it was found that in a large number of cases, tenderness to pressure was more marked on the injured side and could probably be attributed in some cases to the injury of other tissues, in others, to supplementary supply of sensation of the paralyzed muscle by adjacent nerves.

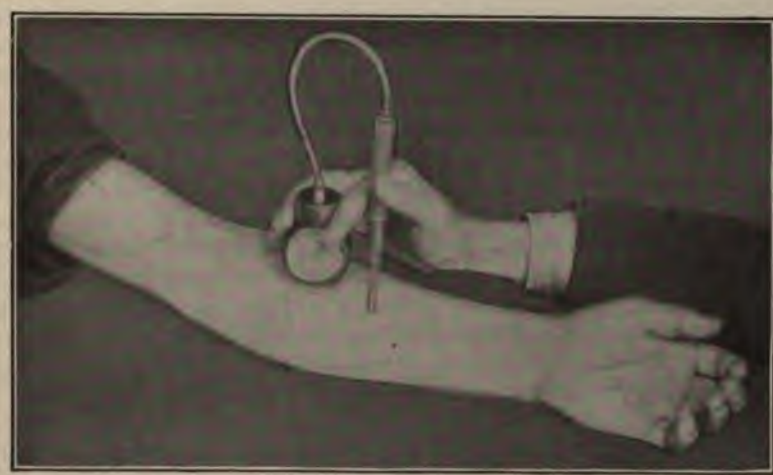

FIG. 282.—Tonometer. Tone relatively measured by amount of pressure, expressed in millimeters of mercury necessary to insert a blunt plunger a certain distance into a muscle mass.

When tone was measured by a tonometer, it was found that only for a short time after an injury of a peripheral nerve was the loss of tone any indication of the severity of the lesion. Even in such an instance the loss of the tone represented only a reflection of the general loss of function. The difference in millimeters of mercury was expressed in the ratio of from 160 to 180 in normal muscle to 40 to 60 in the paralyzed ones. In a very few weeks infiltration, fibroses, and other changes in the muscles and tendons vitiated what significance loss of tone might have (Fig. 282).

Too little is known of the nature of trophic-disturbances to enable us to employ them profitably in interpreting the severity of the lesion. Where protopathic sensibility was lost trophic ulcers were likely to

occur. When an extremity was immobilized, growth of nails ceased. When an extremity was protected by a dressing hypertrichosis was at times observed. Generalized atrophy of the bones indicated only disuse. In other words the trophic disturbances can be employed as an indication of the severity of the nerve lesion only when judged in the light of the presence of other conditions.

As to the absence of hyperesthesia in the regions supplied by an injured nerve as an indication of complete interruption of that nerve, it can be stated definitely that as a matter of fact hyperesthesia is not uncommon in just such cases, when sensation to pin-prick has returned as the result of nerve overlap.

Signs of Regeneration.—The signs of regeneration of a nerve are the manifestations of recovery of function. Among these are return of sensation, both subjective and objective, disappearance of reaction of degeneration, increase of tone, disappearance of atrophy and return of motion.

These manifestations differ in appearance and rate of return as to the pathology of the nerve and as to whether recovery is spontaneous or is consequent to surgical intervention. They are dependent upon the condition of the neuraxones. If descending degeneration has been slight or absent and the nerve recovers spontaneously and rapidly one type of course is followed, if resection and suture have been performed another type is oberved. If little or no degeneration has followed, but a complete physiological interruption has existed for a long time, because perhaps of a constricting band, surgical relief of this morbidity is followed by a regeneration similar in character to that observed in lesions rapidly recovering spontaneously. If descending degeneration is severe or complete and conditions are such that the lesion recovers with no surgical interference, the course of recovery will be very similar to that observed following suture.

Rapidly and spontaneously recovering lesions showed two characteristics, (1) in agreement with others (Sherren), the writer has found that such lesions do not show the dissociation of sensation previously referred to. Here little or no sensibility to pin-prick returns before tactile sensation. Both forms of sensation are absent and return together. This is, in the writer's opinion, due to the fact that the function of overlapping nerves is inaugurated only in the presence of a complete interruption whether it be physiological or anatomical. From 200 peripheral nerve injuries which were incomplete and recovered soon after injury, only three were found where sensibility to pin-prick was present and tactile sensibility absent. The return of sensibility to both pin-prick and touch followed no definite rule as to its location but was in every instance patchy in character; (2) the return of function did not adhere to any definite rate of progression, either as to sensation or motion and often all the muscles innervated by a nerve regained their function suddenly irrespective of their distance from the lesion.

Many cases of complete physiological interruption of a nerve showed their first sign of regeneration at such a time as one would expect it to

occur were the nerve divided at the time of injury and sutured. From this time onward the regeneration progressed exactly as would a sutured nerve. It is reasonable to assume that in this type of severe lesion complete descending degeneration had occurred and conditions permitted the regeneration of the axones. Evidence of regeneration first appeared in from the eighth to ninth month, and it was noticeable that a considerable number of men wounded at about the same time all began to improve together.

The order in which the signs of regeneration appear has been given by Mme. Ath. Benisty[1] as follows: (I) Sensory regeneration, consisting of pain when the skin is pinched, pain when the nerve is pressed below the lesion, formication on pressure of the nerve and spontaneous aching in certain muscles. (II) Arrest of atrophy and return of tonicity. (III) In some cases return of faradic contractility. (IV) Disappearance of objective sensory disturbances. (V) Voluntary movements.

As critical an examination of the clinical signs of nerve regeneration is necessary as was seen to be the case with the signs of complete physiological interruption of a nerve.

In the writer's experience return of pain upon pinching of the skin was many times the first sign of nerve regeneration, but very frequently was not. Only that return of pain to pinching which is found in such areas of skin as are outside the influence of nerve overlap can be used as an indication of the recovery of a nerve.

Frequent spontaneous aching and more frequently a sensation of a "different feeling" in an extremity preceded other signs of nerve regeneration.

Pain upon pressure of the nerve trunk distal to the lesion was found unreliable.

Tinel's sign or peripheral formication upon pressure or light percussion of the nerve trunk distal to the lesion, was found to be practically valueless. Where a nerve is superficial and pressure may be exerted upon it and it alone this sign might have some value. Unfortunately only few of the peripheral nerves have a superficial course and this only for a short distance. Elsewhere other structures may be included in the pressure. Where the sign is elicited by light percussion, the concentric waves of motion transmitted from the percussed spot may stimulate the nerve at a considerable distance.

In any event of 50 cases of recovering lesions, 7 had complete absence of Tinel's sign and 8 had formication for only a short distance from the site of injury. Of fifty irreparable lesions, a complete Tinel's sign was obtained in more than 50 per cent. of cases and only in 7 cases was it completely absent.

Arrest of atrophy and return of tonicity were not profitably employed in those cases recovering some months after injury for reasons already stated.

As to the electrical phenomena of regeneration, it may be well to

[1] The Treatment and Repair of Nerve Lesions, Military Medical Manuals, 1918.

state that in the partial lesions which showed beginning recovery before the eighth month following injury, a response to faradism at times returned before motion. At times motion was present and faradic response absent. The cases showing beginning regeneration following resection and suture, performed not less than six months following injury, never showed any return of response to faradism before the return of motion. The same is true of the cases showing beginning spontaneous regeneration only eight months or more after injury.

Relative to return of sensation, only when that portion of the area representing the anatomic sensory supply of an injured nerve, removed from the influence of overlap, in other words its isolated supply, become sensitive, can we say that regeneration is present. Under this condition at no time did protopathic sensibility return before epicritic. When sensation returned, it became evident in patches scattered over the heretofore analgesic zone and not only upon the borders of this zone. Likewise under this condition, only once in 67 cases of complete physiological interruption of a nerve recovering following surgical treatment did sensation return before motion.

In the interpretation of the significance of return of motion relative to regeneration, proper recognition must be made of supplementary motility. So great does this influence the movement of some segments, that the writer has never been able definitely to state that such movements as he has observed return, following resection and suture of ulnar nerve, was due unquestionably to movement other than supplementary, with the exception of a distinct contraction of the flexor carpi ulnaris. These movements are likewise very confusing in median nerve lesions. Some of the movements which cannot be supplemented in the various nerve lesions are as follows:

In musculospiral lesions, extension of the proximal phalanx of the thumb and abduction of the thumb in the plane of the palm, and extension (not alone tensing) of the proximal phalanges of the fingers. In ulnar nerve lesions, flexion of the proximal phalanges of the ring and little fingers with the distal phalanges extended, and lateral movements of the extended middle finger. In median nerve lesions flexion of the distal phalanx of the index finger and of the thumb. In combined lesions of the ulnar and median all movements of the hand except flexion at the wrist and hollowing of the hand. In external popliteal lesions eversion of the foot.

To determine what nerve has been injured is relatively a simple matter. Loss of function of each nerve is marked by a few very distinctive and easily remembered signs. In each a special supplementary motility develops and a more or less constant area of early return of sensation to prick-pain, due to nerve overlap, appears. In their recovery many of the nerves present an individual character.

MUSCULOSPIRAL LESIONS.

Symptoms.—Following a division of the musculospiral nerve there is lost extension of the first phalanges of the fingers, extension of the

wrist and of the thumb, adduction and abduction of the hand, and if the lesion is high, supination of the forearm when extended and, rarely, extension of the forearm. When the lesion is above the external cutaneous branch, cutaneous sensibility is lost over the dorsal aspect of the radial side of the hand and thumb, and part of the proximal phalanges of the index and middle fingers (Figs. 283 and 284, *3*).

Inasmuch as the radial nerve may have no isolated supply of prick-pain, any return of such pain in the area subserved by the radial nerve cannot be interpreted as a sign of nerve regeneration. In other words, the median, ulnar, musculocutaneous and antibrachii posterior branch of the musculospiral completely overlap the supply of the radial.

FIG. 283.—Musculospiral lesion.

Normally, extension of the wrist is accomplished by the extensors carpi radialis and ulnaris, extensor longus pollicis, and sometimes by the extensor communis digitorum.

In a lesion of the musculospiral nerve below the elbow, paralysis of the extensors of the fingers may occur without involvement of the extensors of the wrist. Under these conditions the patient cannot extend the wrist if at the same time he attempts to extend the fingers, but if he flexes the fingers extension of the wrist may then be accomplished.

Supplementary Motility.—Of the supplementary movements developed in musculospiral paralysis a few of the more prominent ones will be mentioned. Dorsal flexion of the hand may be produced by ener-

getic contraction of the flexors of the fingers (Fig. 285). In other words, upon attempting to close the hand it is extended at the wrist. In some cases strong contraction of the pronator radii teres will produce extension of the hand upon the forearm. During this movement the head of the radius is strongly depressed toward the palm and the hand deviates to the ulnar side. The extension of the wrist is probably due to

FIG. 284.—Sensory changes in peripheral nerve lesions: *1*, ulnar; *2*, median; *3*, radial *4*, combined ulnar and median; *5*, external popliteal; *6*, sciatic. Black areas analgesic and anesthetic. Shaded areas, anesthetic.

two factors: (1) the lengthening of the extensor tendons and muscles; (2) to a leverage exerted upon the trapezoid by the head of the radius. At times, in addition to the contraction of the pronator, there is seen strong adduction and opposition of the thumb against the proximal phalanx of the index finger. At the same time resistance is made to this action by the contraction of the lumbricale muscle and the hand is extended upon the forearm to a noticeable degree. Although never

as complete or as strong as when the extensor pollicis is spared, the adductor pollicis and the flexor brevis pollicis may produce extension of the distal phalanx of the thumb in musculospiral palsy.

FIG. 285.—Extension of the wrist in musculospiral palsy by means of supplementary motility.

FIG. 286.—Complete motor recovery of musculospiral.

Pathognomonic Signs of Injury.—Three pathognomonic signs of musculospiral injury are (1) wrist-drop; (2) inability to extend the proximal phalanges of the fingers and (3) inability to extend the thumb.

Signs of Complete Recovery.—Ability to place the little finger on the seam of the trousers with the fingers extended and the palm to the front is evidence of complete motor recovery (Fig. 286).

MEDIAN NERVE.

The median nerve supplies all the muscles of the anterior surface of the forearm except the flexor carpi ulnaris and inner portion of the flexor profundus digitorum.

In the hand it supplies the muscles of the thenar eminence except the deep head of the flexor brevis pollicis. It also supplies the outer two lumbricales.

Signs of Injury.—In division of the median nerve it is supposed that the patient is unable to pronate the forearm, to tense the palm, to contract the flexor carpi radialis, to flex the second phalanges of any finger, to flex the distal or third phalanges of the index and middle fingers, to flex the proximal phalanges of the index and middle fingers, to flex the second phalanx of the thumb, to oppose or abduct the thumb, and, finally, fully flex the proximal phalanx of the thumb (Figs. 287 and 288).

FIG. 287.—Median nerve lesions showing trophic ulcers on index and middle fingers.

The sensory supply is distributed on the palm to the radial half of the ring finger, the middle and index fingers and the thumb and a corresponding part of the palm. On the dorsum it supplies the distal two and one-half phalanges of the middle and index fingers and the radial half of the distal two phalanges of the ring finger (Fig. 284, *2*).

Return of sensation to prick-pain in any part of the median supply, except the palmar and dorsal surfaces of the two distal phalanges of the index and middle finger, cannot be interpreted as a sign of regeneration, but must be attributed to the overlap of the radial and musculocutaneous nerves.

Supplementary Motility.—Contrary to expectations, section of the median nerve is frequently followed by but little disturbance. Flexion of the proximal phalanges of the inner two fingers is preserved because the lumbricales of these two fingers are supplied by the ulnar nerve.

FIG. 288.—Median nerve lesion.

At times the middle finger may likewise receive its supply from the ulnar. Flexion of the proximal phalanges of the middle and index finger may result from strong contraction of the flexor profundus digitorum, the lumbricales originating in its tendon, and from exten-

FIG. 289.—Opposition of thumb in median nerve lesions by means of supplementary motility.

sion of the distal phalanges by means of the interossei. Flexion of the second phalanges of the inner two fingers occurs as the result of an accompaniment of this movement to the normal flexion of the proximal and distal phalanges. This may also be true of the middle finger.

Opposition of the thumb may be simulated by the action of the adductor pollicis and the inner head of the flexor brevis pollicis with the terminal phalanges of the little finger flexed (Fig. 289). Slight flexion of the distal phalanx of the thumb may result as a rebound phenomenon following strong extension.

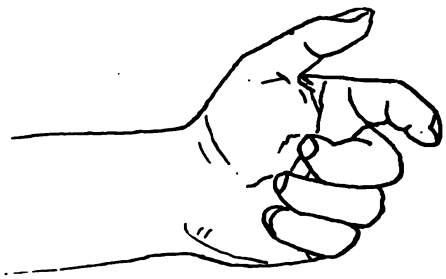

FIG. 290.—Sign of median palsy: failure to flex index finger in making fist.

Pathognomonic Signs of Injury.—Three pathognomonic signs of paralysis of the median nerve are: (1) Inability to oppose the tip of the thumb to the tip of the little finger; (2) to fully flex the index finger; and (3) to flex the distal phalanx of the thumb as in clenching a fist (Figs. 290 and 291).

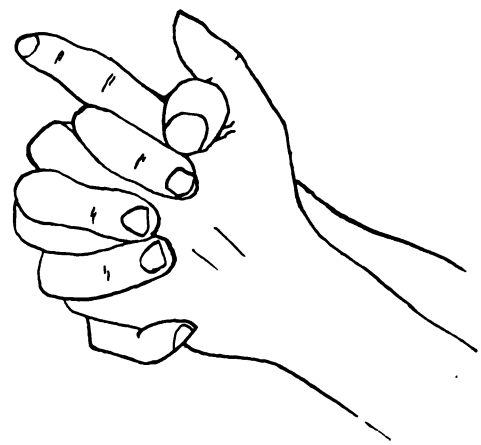

FIG. 291.—Sign of median palsy: failure to flex index finger in clasping hands.

Signs of Motor Recovery.—Complete flexion of the index finger, as brought out by making a fist or clasping the hands together is a good sign of motor recovery of the median nerve (Figs. 292 and 293). The median nerve is preëminently the seat of painful lesions giving rise to the syndrome known as causalgia. This condition is characterized by severe paroxysmal pains of burning character. They are brought on or prolonged by dependent posture of the hand. Exposure to air or heat, noise, sudden hiccoughing and emotional causes all produce

The skin over the affected area becomes fine, pinkish and
ıt-like. Often, because of continuous application of moist

FIG. 292.—Recovery of median nerve.

as towels (in an effort to diminish the pain) extensive excoria-
seen.

FIG. 293.—Recovery of median nerve.

ULNAR NERVE.

of Injury.—The ulnar nerve supplies the flexor carpi ulnaris
er portion of the flexor profundus digitorum. In the hand it
the muscles of the hypothenar eminence, all the interossei,
inner lumbricales, and in the thenar eminence the adductor
and the short head of the flexor brevis pollicis.
supposed that section of the ulnar nerve produces inability to

flex the proximal or distal phalanges of the ring and little fingers, to abduct or adduct the fingers, to extend the second and distal phalanges of any of the fingers, to adduct the thumb, to contract the flexor carpi ulnaris and to abduct or oppose the little finger (Figs. 294 and 295). The

FIG. 294.—Ulnar nerve lesion.

sensory supply is to the skin over the inner part of the palm, as far as the wrist, to the little finger and one-half of the ring finger on the palmar surface and the little, ring and one-half of the proximal phalanx of the middle finger on the dorsum (Fig. 284, *1*).

FIG. 295.—Ulnar nerve lesion.

Return of prick-pain only over the palmar or dorsal surface of the distal part of the little finger can be interpreted as a sign of nerve regeneration.

Supplementary Motility.—With the possible exception of lateral movements of the middle finger, all other movements commonly understood as lost, following section of the ulnar nerves, may be imitated by supplementary motility. As a result the writer has found it impossible to state when any such movement could be interpreted as a sign of regeneration. Such movements may increase in strength from supplementary motility alone. In this instance, therefore, definite signs of sensory regeneration furnish the best proof of the regeneration of the nerve.

Slight flexion of the proximal phalanx of the ring finger may be obtained from the contraction of the flexor profundus digitorum pulling upon its lumbricale muscle. Extension of the second and third phalanges of all the fingers is partly preserved for the following reasons: innervation of the first and second dorsal interossei by the median; passive extension of the second and third phalanges by flexion of the proximal ones, thereby shortening the interossei; and, the influence of the contraction of the extensor communis digitorum.

In adduction of the thumb the extensor longus pollicis is a prime mover and in ulnar nerve lesions it may supplant the loss of the adductor pollicis (Fig. 296).

FIG. 296.—Adduction of thumb by extensor longus pollicis.

Abduction of the fingers away from the midline may result from forced extension of the first phalanges. Abduction of the index finger may be produced by strong abduction and extension of the thumb (Fig. 297). When the hand is abducted to the ulnar side, contraction of the extensor indicis produces slight adduction of the index finger.

Pathognomonic Signs of Injury.—Three pathognomonic signs of ulnar palsy are, besides the atrophy of the first dorsal interosseus, with clawing of the two inner fingers, (1) inability to firmly grasp flat objects between the thumb and forefinger (paralysis of the adductor pollicis); (2) inability to flex the proximal phalanges with the distal ones extended (lumbricales palsy) and, (3) inability to abduct or adduct the little finger.

Signs of Motor Recovery.—Let the palm be placed flat upon a table with the fingers apart, then the middle finger should be moved inward and outward and finally the table scratched with the nail of the little finger without moving the wrist.

FIG. 297.—Abduction of fingers by extensor communis digitorum.

FIG. 298.—Combined ulnar and median lesion.

COMBINED LESIONS OF THE ULNAR AND MEDIAN.

In combined lesions of the ulnar and median nerves all flexor movements are lost and the thenar and hypothenar muscles paralyzed (Figs. 298, 299 and 300.) Typical of this condition is the ape-hand with the thumb in the same plane as the fingers.

It should not be forgotten that the extensor ossis metacarpi pollicis can flex the wrist, at times to a marked degree in such combined palsies.

Return of sensation to prick-pain in the radial part of the palm cannot be used as a sign of nerve regeneration (Fig. 284, *4*). Dependent

FIG. 299.—Combined ulnar and median lesion.

upon whether the lesion affects the small hand muscles alone or all the muscles of the anterior surface of the forearm and hand, is the appearance of certain characteristic deformities. A few of the various types which may be seen are here illustrated.

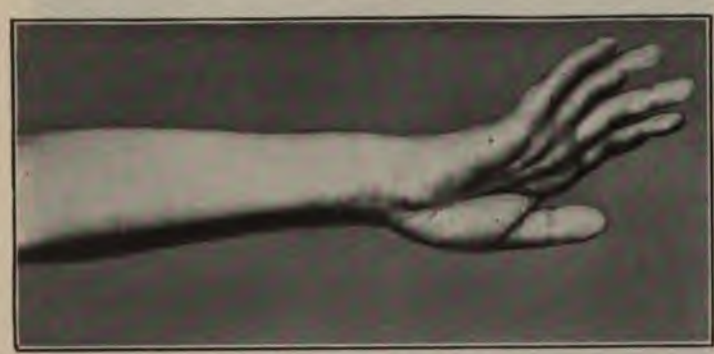

FIG. 300.—Combined ulnar and median lesion.

BRACHIAL PLEXUS LESIONS.

Brachial plexus lesions in civil practice have been divided as to type into lesions of the primary cords, the secondary cords and root lesions. The secondary cords usually spoken of as the cords of the brachial plexus, have been the most frequent type of lesions observed. The cases have likewise been divided into upper arm paralysis as the Erb-Duchenne type of injury of the fifth and sixth cervical nerve and of the lower arm paralysis, or the Klumpke type.

Direct lesions of the brachial plexus due to war wounds present no

clearly defined classification. Ordinarily immediately following inju
there is a complete paralysis of the brachial plexus which, as the effe

FIG. 301.—Upper brachial plexus lesion. Paralysis of deltoid.

FIG. 302.—Lower brachial plexus lesion. Analgesia over outer surface of forearm a
within outlined area.

of the concussion disappear resolves itself into one or another type
involvement of one or more cords, or an incomplete type of to
brachial plexus paralysis.

Lesions of the inner cord of the brachial plexus are evidenced by paralysis of all the intrinsic muscles of the hand and some or all of the flexors of the wrist and fingers. Lesions of the posterior cord are evidenced by paralysis of the muscles supplied by the circumflex, musculospiral and subscapular nerves. Lesions of the outer cord result in paralysis of the muscles supplied by the musculocutaneous and median nerve with the exception of the intrinsic muscles of the hand (Figs. 301 and 302).

FIG. 303.—Sciatic nerve lesion.

BRACHIAL PLEXUS LESIONS WITH ACCOMPANYING CORD LESIONS.

One of the interesting things observed in lesions of brachial plexuses has been the coincidence of lesions of the spinal cord with these injuries. These spinal cord lesions have been of two types: one, fortunately the more frequent, occurring immediately with the brachial plexus injury, in which the soldier falls with a paralysis in his four extremities which rapidly develops into a hemiplegia of the spinal type, and therefore a Brown-Séquard paralysis. When examined at this time

there is found, in addition to the brachial plexus on the side injury, a paralysis of the same leg, with slight loss of touch o side, loss of tendon and vibration sense, and on the opposite sid of pain and temperature sense. At times a paralysis of the o arm of a root type may persist for a certain period. In a rel short time the paralysis of the leg disappears leaving only a b plexus palsy. The other type shows a progressive developm softening of the cord, which is irreparable.

FIG. 304.—External popliteal lesion.

SCIATIC NERVE.

The sciatic nerve supplies, in the thigh, the biceps femoris membranosus and semitendinosus. It divides into its t branches the external and internal popliteal which supply muscles of the leg.

When the lesion occurs in the sciatic nerve in the thigh it may the internal popliteal or the external popliteal portions or both. both are affected no active movement of the leg is possible, fre the flexor muscles of the thigh escape (Fig. 303).

The sensory distribution of the sciatic is better illustrated than described (Fig. 284, *6*).

EXTERNAL POPLITEAL.

The external popliteal branch of the sciatic supplies the tibialis anticus, the extensor longus digitorum, the extensor propius hallucis, the peroneus tertius, longus and brevis, and the extensor brevis digitorum.

Signs of Injury.—Section of the external popliteal is followed by foot drop with inability to dorsalflex the foot, extend the toes or abduct the foot (Fig. 304).

The sensory supply of the external popliteal nerve is illustrated and in this distribution loss of tactile sense is found (Fig. 284, *5*).

The isolated supply to prick-pain of the external popliteal nerve is a narrow band extending from a point a little above the junction of the lower and middle one-third of the outer surface of the leg diagonally across the dorsum of the foot to a point over the middle of the metatarsal bone of the great toe, and is interrupted by an analgesic area at the junction of its lower and middle thirds. The return of prick-pain in areas outside this distribution cannot be interpreted as a sign of nerve regeneration.

In the lower extremity the principal supplementary movements have been observed in the toes as the result of rebound action following a movement in a direction opposite to the one intended.

INTERNAL POPLITEAL.

The internal popliteal nerve supplies the popliteus, the plantaris, gastrocnemius, soleus, tibialis posticus, flexor longus digitorum, flexor longus hallucis, the abductors of the great toe, and the plantar muscles.

Signs of Injury.—Lesions of the internal popliteal are followed by loss of plantar flexion of the foot, adduction of the foot, flexion and separation of the toes.

Painful lesions are not uncommon and in this respect, as in the occurrence of trophic disturbances, this nerve resembles the median.

RECOVERY OF PERIPHERAL NERVE LESIONS.

The striking feature of the clinical picture of early nerve lesions was the large percentage of marked and rapid improvement. An analysis of the first 100 cases seen in Base Hospital No. 13, showed that after three months, 61 cases had been discharged. Twenty of these cases had sufficiently recovered to be sent to convalescent and replacement camps. Thirty-nine cases remained in the hospital. Twenty of these were manifestly only partial lesions, and only 5 were so severe as definitely to indicate the necessity for surgical interference.

There were probably 10,000 peripheral nerve lesions sustained in

battle by the American Expeditionary Forces. To the writer's kn edge not more than 3000 cases have been classified as peripheral n lesions in the hospitals of the United States. In other words, thirds of the cases of peripheral nerve lesions had sufficiently recov so that this lesion was of minor importance.

From 488 available records of 520 cases of peripheral nerve les seen in U. S. A. General Hospital, No. 28, Fort Sheridan, Illinois, had either recovered or were recovering.

From the cases coming under the writer's personal observation it w seem that about one-seventh of the total number of peripheral n lesions incurred in battle come to operation. In some clinics the nur operated upon is very much greater, but if our conservative atti results in as great a number of recoveries, then no more than seventh of all the cases should come to operation.

SURGERY OF THE SPINAL CORD.

By WILLIAM L. RODMAN, M.D.,

AND

J. STEWART RODMAN, M.D.

ANATOMY OF THE SPINAL CORD.

The spinal cord is well protected, lying in the spinal canal of the vertebral column. The weakest point in the vertebral column is between the second and third cervical vertebra, although the junction of the thoracic and lumbar curves is the most liable to injury, since here a fixed part joins the most movable. The bony spinal canal varies somewhat in shape, being large and triangular in the cervical and lumbar region, smaller and round in the thoracic region and still smaller and somewhat flattened in the sacral region. The vertebral column curves forward in the cervical and lumbar regions and backward in the thoracic and sacral region. The latter curves are primary to accommodate the thoracic and pelvic viscera, while the former are compensatory to allow for the erect posture; these curves add to the strength of the vertebral column as well as increase its elasticity and resistance to trauma.

The *spinal meninges* also afford covering and protection to the cord as the cerebral meninges do the brain. The spinal dura mater is a continuation of the inner layer of the cerebral dura and does not, as the latter, act as periosteum. The spinal dura extends from the foramen magnum to the third sacral vertebra, from whence it continues to the coccyx as a fibrous cord, the coccygeal ligament. Upon the dura and in the space between it and the vertebræ are veins and fat. The veins communicate through the ligamenta subflava with the dorsal spinal veins. The *spinal arachnoid* is continuous at the foramen magnum with the cerebral arachnoid and blends with the dura at the third sacral vertebra. The space between the dura and arachnoid is slight, but between the arachnoid and the pia mater is well marked. This is the subarchnoid space which communicates with the same space of the brain by the foramen of Magendie in the midline and by the foramina of Key and Retzius laterally. Thus it is that lumbar puncture will drain the cerebrospinal fluid from the brain cavities as well as spinal canal. Across the subarachnoid space posteriorly and in the midline is the septum posticum and laterally the ligamenta subflava. No bloodvessels or nerves are found in the arachnoid.

The *pia mater* closely invests the cord, its chief function being to

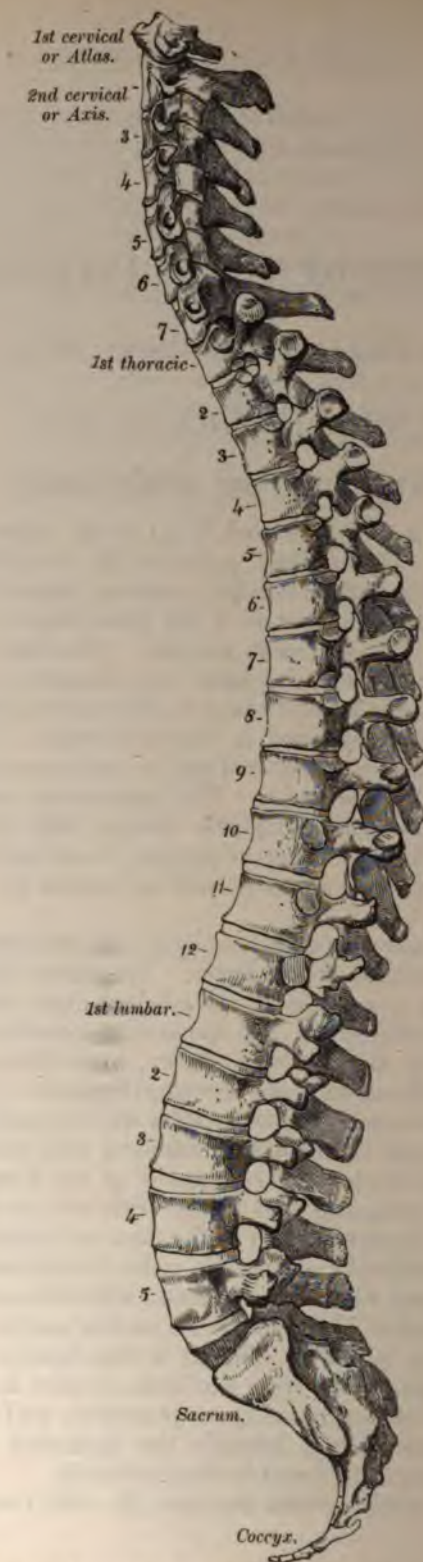

FIG. 305.—Lateral view of the vertebral column. (Gray.)

carry the bloodvessels of the cord. It extends prolongations to the arachnoid and dura, the septum posticum and ligamentum denticulatum.

The *spinal cord* is a part of the central nervous system, being a continuation downward of the medulla oblongata. It extends from the occipito-atloid junction to the body of the second lumbar vertebra, is eighteen inches long and weighs about one ounce. The cord approaches the cylindrical in shape and in the cervical and lumbar

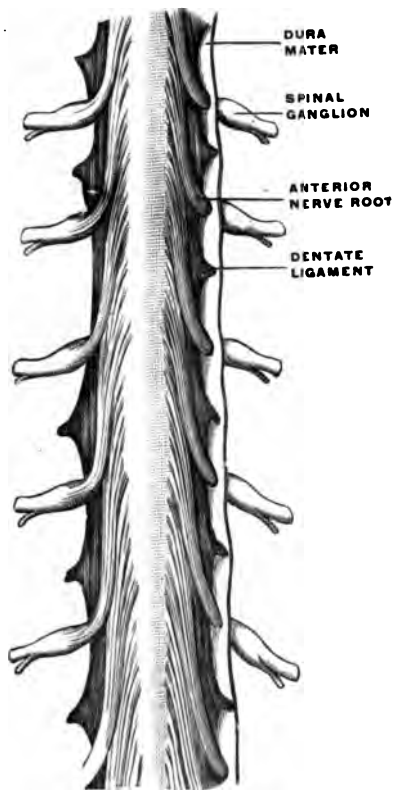

FIG. 306.—The dentate ligament. The dura has been opened and turned back. The ventral surface is seen. (Hirschfeld.)

regions it increases in its diameter. These latter enlargements are called the cervical and lumbar swellings respectively, the former extending from the third cervical to the second thoracic vertebra and from it come the nerves to the upper extremities. The lumbar swelling begins at the ninth thoracic and from it come the nerves to the lower extremities. The uppermost limit of the spinal cord is the lowest level of decussation of the pyramidal tracts in the medulla and the lower limit is the extension of the conus medullaris known as the filum terminale. In the three months' fetus the spinal cord extends to the end of the

spinal column, has risen at birth to the third lumbar vertebra and in adults to the lower border of the first or body of the second lumbar vertebra.

It is divided into 31 segments as follows: 8 cervical, 12 dorsal, 5 lumbar, 5 sacral and 1 coccygeal. A segment of the cord is that portion which sends out a pair of anterior or motor roots and receives a pair of posterior or sensory roots. The cord is bilaterally

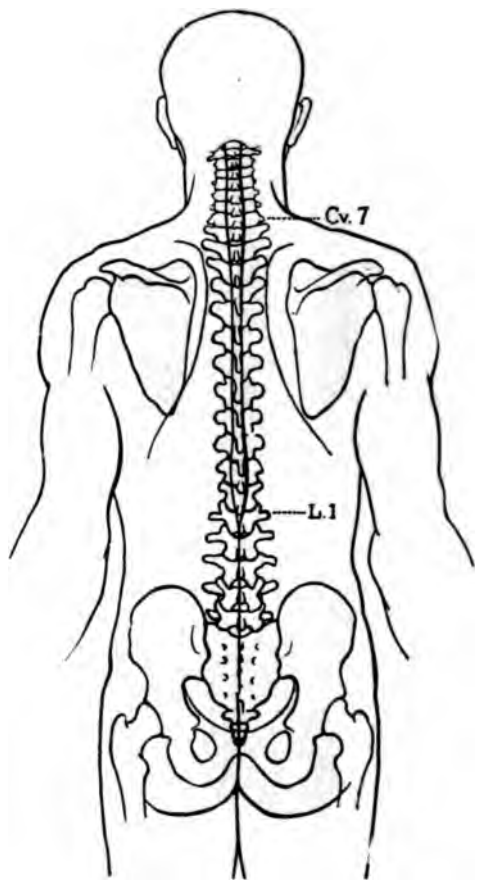

FIG. 307.—Relation of spinal cord to the dorsal surface of the trunk. (Gray.)

symmetrical, composed of gray and white matter, and presents on its surface certain fissures. In the midline anteriorly is the ventromedian fissure, midline posteriorly dorsomedian fissure about one-quarter way around the circumference are the dorsolateral fissures, while between the latter and the dorsomedian fissure are the dorsointermediate fissures.

The gray matter of the cord is centrally placed, arranged in three horns: anterior, lateral and posterior, on either side connected by the

gray commissure, so that the entire gray matter resembles the letter "H." The white matter encloses the gray matter. (See Section of the Cord.) In the center of the spinal cord runs a canal which is a continuation of the cerebral cavities and is called the central canal. The conduction paths of the cord are tracts of nerve fibers, some carrying stimuli from the brain to the periphery, others from the periphery to the brain. The former are motor tracts and the latter sensory. The motor tracts are the direct pyramidal and the crossed pyramidal. The direct pyramidal tracts are continuations of the pyramids of the medulla. They are found in the ventral column next to the ventromedian fissure, diminishing in size from above downward to disappear about the level of the first lumbar nerve. These tracts are called

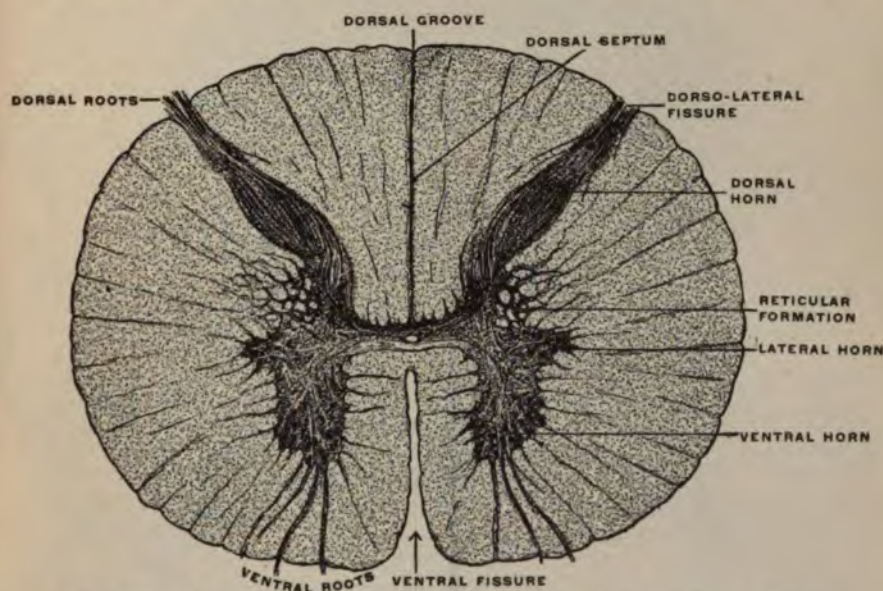

FIG. 308.—Trans-section of the spinal cord at the mid-thoracic region. (Gray.)

direct, since they occupy the same side in the brain and cord. The *crossed pyramidal tracts* are found in the lateral column near the posterior horns. They are a continuation of other fibers of the pyramids, which decussate in the medulla. The sensory tracts are those of Goll and Burdach, ascending lateral (Gowers) and direct cerebellar. The tracts of Goll and Burdach are to be found in the dorsal column, the former next to the dorsomedian fissure, the latter between Goll's and the posterior gray horn. Gowers's tracts, or the ascending lateral, are located in the lateral column, anteriorly and to the outer side; it occupies the entire length of the cord and increases from below upward. The direct cerebellar is also in the lateral column between the crossed pyramidal tract and the margin, and ascends to the cerebellum. This tract appears at the level of the eighth or ninth thoracic nerve root and

increases as it ascends. The *ventrolateral association tract* or *bundle* runs from the lateral column around the anterior horns and connect different levels of the cord, as do the deep lateral association tracts, which are placed deep in the lateral column.

The spinal nerve roots are anterior or motor, posterior or sensory, a pair of each coming from a segment of the cord. After running a varying distance in the dura these roots perforate the latter, join each

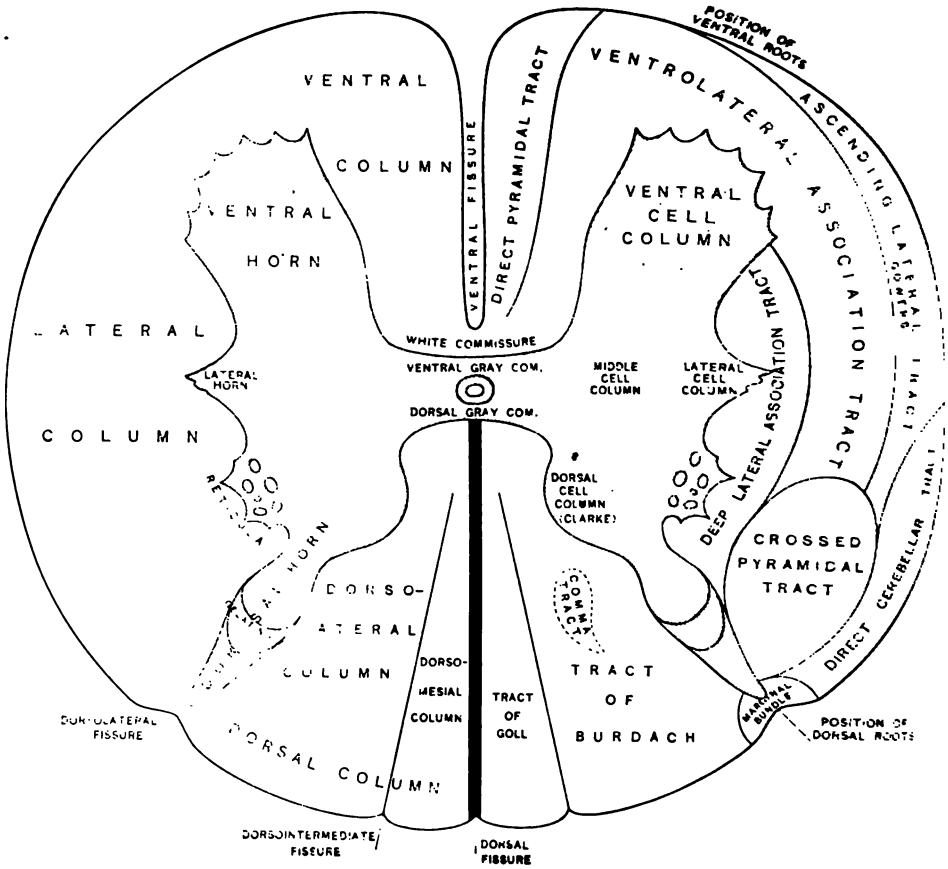

FIG. 309.—Diagrammatic ideal transverse section of the spinal cord. On the left side are shown the gross divisions; on the right side, the conduction paths. (F. H. Gerrish.)

other to form the spinal nerves, which are, therefore, mixed nerves, containing both motor and sensory fibers. On the posterior roots after they penetrate the dura and before they join the anterior roots are found swellings known as the posterior root ganglia. The place of exit from the spinal cord of each nerve root is at the bottom of its corresponding vertebra. Thus the second lumbar root leaves at the bottom of the second lumbar vertebra. The exceptions to this rule

are found in the cervical region, namely, the first cervical root makes its exit at the top of the first cervical vertebra and the eighth cervical root at the bottom of the seventh cervical vertebra. The nerve roots from the lumbar and sacral cord taken together are called the cauda equina.

FIG. 310.—Formation of a spinal nerve. (Testut.)

PHYSIOLOGY OF THE SPINAL CORD.

There are two functions of the spinal cord, the first being to carry impulses to and from the brain. In the anterior horns of gray matter will be found motor cells which control motion in the limbs, trunks and abdomen. They are the trophic centers of the motor roots and nerve fibers. Rapid atrophy follows in the muscles supplied by the particular nerve cells if destroyed, as well as degeneration, the reaction of degeneration and absence of electrical reaction. The paralysis is flaccid (peripheral neuron paralysis), deep reflexes being lost as the reflex arc is broken. After interference with the pyramidal tracts (central neuron paralysis) the paralysis is spastic as the inhibitory fibers are cut off. Cerebral diplegia (Little's disease) furnishes a good example of this type of paralysis.

The sensory fibers concerned with touch sensation and muscle sense, entering the spinal cord by way of the posterior roots, ascend in the columns of Goll and Burdach of the same side, first entering into the column of Goll and passing over at a higher level to the column of Burdach. These fibers decussate in the medulla just above the decussation of the motor tracts and then pass into the sensory cortex. The fibers which transmit sensation for pain and temperature entering the posterior horns by way of the posterior roots, decussate and pass upward in the ascending lateral tracts. These fibers, as well as those concerned in the transmission of touch sensation after their respective decussations in the medulla and spinal cord, pass by way of the median

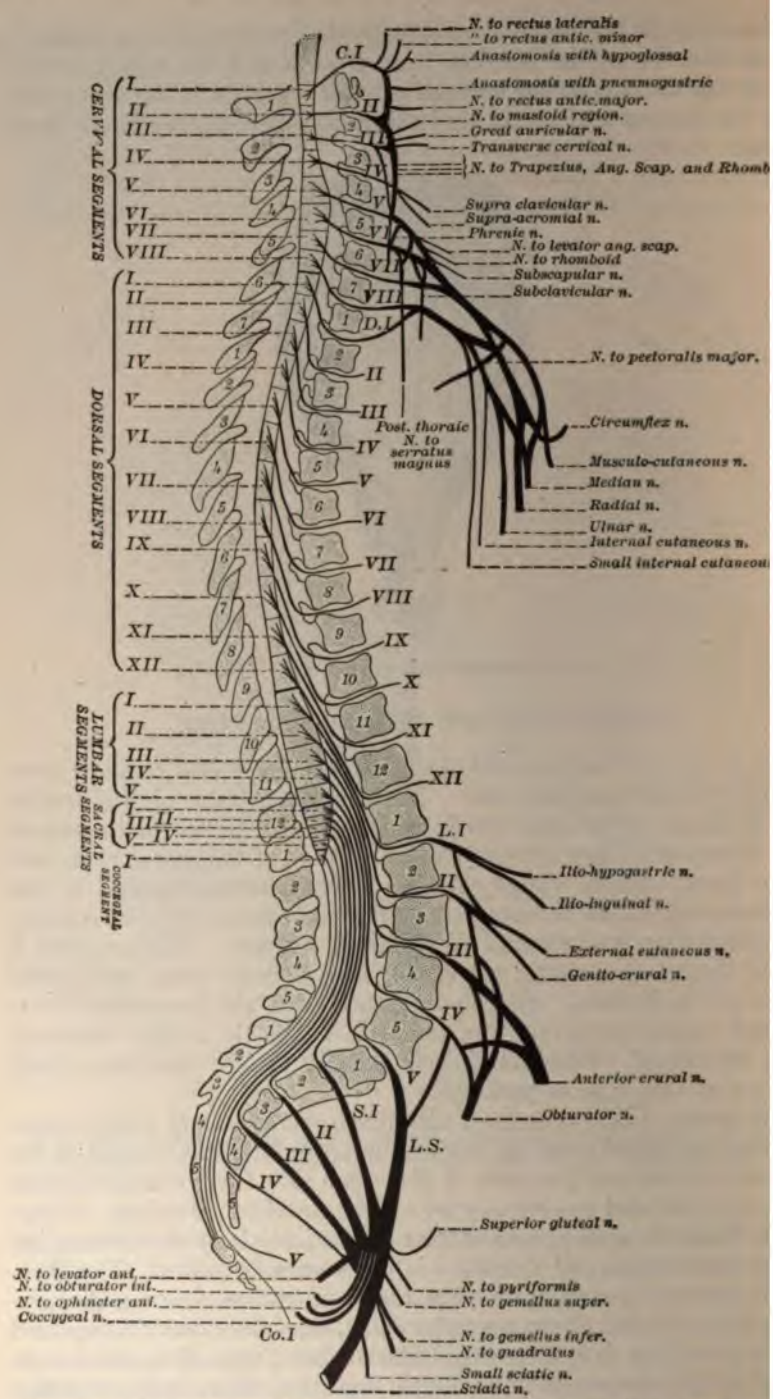

FIG. 311.—The relation of the segments of the spinal cord and their nerve roo the bodies and spines of the vertebræ. (Dejerine et Thomas, Mal. d. l. Moelle Épir Paris, 1902.)

FIG. 312.—Subdural meningocele. The spinal cord and arachnoid membrane are normal. The sac is formed by the dura and skin. (Elsberg's Surgery of the Spinal Cord. copyright by W. B. Saunders Company.)

FIG. 313.—Subarachnoid meningocele. The arachnoid layer forms part of the wall of the sac. (Elsberg's Surgery of the Spinal Cord, copyright by W. B. Saunders Company.)

to the optic thalamus of the same side and then throug
erior portion of the posterior limb of the internal capsule
cal sensory centers in the postcentral convolution of the same

FIG. 314.—Subarachnoid meningocele with prolapse of nerve roots. (Elsberg's
of the Spinal Cord, copyright by W. B. Saunders Company.)

FIG. 315.—Myelomeningocele. Changed cord tissue forms part of the
(Elsberg's Surgery of the Spinal Cord, copyright by W. B. Saunders

The spinal centers controlling the *bladder and the rec*
centers are located in the second, third and fourth sa
Fibers that have to do with the bladder and rectal
descend in the lateral columns of the cord. The *cilio*

whose stimulation causes the pupil to contract, extends from the sixth cervical to the third thoracic segment, its fibers leaving the cord with the eighth cervical and first thoracic roots to join the sympathetic. The spinal vasomotor centers extend from the second thoracic to the second lumbar segments.

SPINA BIFIDA.

In the embryo the medullary tube and its canal are formed by the epiblastic medullary ridges. Between the medullary tube and the epidermis is to be found mesoblastic tissue from which are developed the meninges, vertebra, spinal muscles and fibrous structures. The completion of the neural arch is brought about by a fusion of the laminæ, each of which is ossified from a separate center beginning in the upper dorsal region and extending in both directions. Failure of union of the laminæ usually occurs at the lower part of the spinal column. Defects of development of the medullary tube and spinal column result in a hernia-like protrusion in the midline of the back known as spina bifida. This hernia-like sac may or may not contain the cord or nerve roots, but is always formed by some of the meninges. Wernitz places the frequency of spina bifida at 1 in 1000 births.

Etiology.—The etiology of spina bifida is not clear, although several theories have been advanced to explain its development. Virchow would explain the occurrence by the presence of amniotic bands and local inflammatory process. A disproportion between the growth of the canal and the cord (von Recklinghausen) as well as imperfect separation of the skin and medulla (March and Rauke) have also been advanced as possible explanations.

There are several varieties of spina bifida. If there has been a complete absence of union of the walls of the medullary canal there results a variety known as rachischisis. If complete, it extends the entire length of the canal, if partial, it is limited to a few vertebra. On either side the pia is lined by epithelium (zona epitheliosa) while the scanty remains of the cord proper is represented by a reddish-brow ı, velvet-like band on the pia (zona medullovasculosa). If there is an increase in the amount of fluid in the subarachnoid space a tumor is formed on the dorsal wall of which runs the zona medullovasculosa longitudinally. This is the myelomeningocele of von Recklinghausen. In this variety the sac is lined by pia, the inner side being outside. As there is a defect in the skin in the above varieties, infection readily enters and meningitis results. Fortunately, children born with either rachischisis or myelomeningocele are rarely viable as a failure in the development of the cord or secondary degeneration of it causes paralysis of the legs and sphincters. There are usually other defects of the bladder, skull or abdominal wall, and most of these unfortunates are stillborn. If the medullary canal closes the epidermis always unites, though the mesodermic tissues may show defects. A cleft in the dura accompanies one in the vertebra while the pia and arachnoid

are always closed if the cord in its development has formed a central canal.

The remaining forms of spina bifida, known as spina bifida proper, are (*a*) meningocele, (*b*) meningomyelocele, (*c*) myelocystocele. All of these forms have in common clefts of the bony canal and of the dura as a rule. The simplest form of all is the *extradural meningocele*, in which the spinal cord lies within the normal arachnoid, the defect involving only the vetebral arches and the dura. In this variety there is a collection of fluid between the skin and the arachnoid. Extradural meningocele are rather rare, the more usual form being the *subarachnoid meningocele*, which comprises approximately 10 per cent. of the cases of spina bifida. In this variety the collection of fluid is beneath the arachnoid which forms one of the walls of the sac. As a rule the pedicle of these protrusions is slender, the defect in bone being small and to either side of the midline. If the latter is low down in the spinal column nerve roots of the cauda equina may prolapse and be found in the sac. The *meningomyelocele* is the most common variety; here the cleft is large, involving several vertebra, the sac has a wide base and is usually subdivided by partitions. The cord itself is abnormal and it or nerve roots are usually attached to and spread over the walls of the sac.

The myelocystoceles are sometimes called syringomyeloceles, because fluid accumulates in the central canal, distends it and flattens out the overlying cord substance. The latter becomes atrophied. In this variety the sac does not contain nerves, and club feet, umbilical hernia and other congenital deformities often accompany it. Spina bifida may occur in any part of the spine but is much more common in the lumbar and sacral region.

Diagnosis and Prognosis.—While it is usually possible to make a diagnosis of spina bifida on inspection it is not easy to differentiate the actual variety. In fact, only operation, as a rule, will reveal the true characteristics of the contents of the sac. Of course, rachischisis and the myelomeningocele of von Recklinghausen have characteristic appearances and do not, as a rule, offer much difficulty associated, as they are, with other deformities. As has been said, such children are rarely viable, so that these varieties offer a hopeless prognosis from the standpoint of surgical cure.

Of the varieties of spina bifida proper, meningoceles offer the best prognosis and are the most amenable to operative cure. The diagnosis of pure meningocele may be made if the mass is pediculated, if there is little or no increase of size when the child cries and if no sensory or motor disturbances can be discovered.[1] If the protrusion becomes larger when the child cries or smaller on pressure with distention of the fontanelle it is certain that one is dealing with either subdural meningocele or some form of meningomyelocele. Paralysis of the extremities, bladder or rectum are much more common in the severe forms of

[1] Elsberg: Diseases of the Spinal Cord and its Membranes, p. 179.

spina bifida. It is extremely difficult to interpret sensory disturbances in infants. Other means of diagnosis may be used, as transillumination of the sac and *x*-ray. In general the prognosis of spina bifida is most unfavorable.

Of 649 deaths from spina bifida in England in 1882,[1] 612 occurred in the first year. Most of those who live to the fifth year have meningoceles. The usual causes of death in those who survive the first few months are rupture of the skin with consequent meningitis and urinary sepsis resulting from paralysis of the bladder.

Treatment.—The treatment of spina bifida is operative. Preparatory to operation the skin of the back should be given careful attention and the infant's strength built up by proper feeding, preferably, of course, by the breast. The question of the best time to operate upon these cases has been a matter of considerable discussion in the literature. Some[2] advise operation within the first few months of life, while others[3] advise waiting a few years. Moore thinks it best to operate after five years. Undoubtedly the mortality has been very high when operation has been done in the first few months of life, ranging from 35 to 50 per cent. After the fifth year it drops to about 5 per cent., but, of course, these are the favorable cases that would have lived without operation. If surgery is to benefit the majority of these unfortunates, intervention must be undertaken early, as rupture of the sac, causing meningitis, paralysis of the bladder, etc., will result in death unless surgical relief is forthcoming. Meningoceles are the most favorable variety for operation. The severe forms, rachischisis and myelomeningocele of von Recklinghausen, are entirely inoperable. Opinions differ as to the propriety of operating upon myelocystocele; hydrocephalus, if marked, is a contra-indication to operation. Elsberg states that he has seen marked improvement follow operation in cases associated with mild hydrocephalus. Paralysis of the lower limbs, while in itself not a contra-indication to operation, is rarely if ever improved by the procedure since, it is usually the result of degenerative changes in the cord. If the sac seems on the point of rupturing the tension may be relieved by the introduction of a fine needle and aspirating some of the fluid. Injecting of irritating fluids (as Morton's) have been abandoned as useless.

Technic of Operation.—The simpler the technic the better, as infants are never good surgical risks. The more elaborate methods, as fracture of the rudimentary arches and suture of their free ends (Dollinger), the pedunculated flap of bone and periosteum from the sacrum (Selenko) or from the crest of the ilium (Bobroff) and the transplantation of bone and periosteum from animals (Robson and others) have been discarded. If the skin is ulcerated it can be treated with carbolic

[1] Woolsey: Keen's Surgery, ii, 823.
[2] Sochtleben: Zentralbl. f. Chir., 1904, p. 340.
[3] Moore: Surg., Gynec. and Obst., August, 1905, and Broca, quoted by Woolsey: Keen's Surgery, ii, 824.

acid neutralized by alcohol or tincture of iodin. The infants should be placed in the prone or nearly prone position, on a hot-water bag and anesthetized by chloroform or ether by the open method. We prefer chloroform anesthesia, as a general rule, in such young children. The general field of operation is prepared by the usual technic (iodin method). The skin incision will vary somewhat, depending upon the amount of redundant skin present. Usually the skin overliyng the sac may be sacrificed because of the redundance, but enough should be kept to allow for flaps which will meet a little to one side of the median line. In meningoceles especially it facilitates dissection of the sac to allow it to remain unopened until the dissection is carried well down to the pedicle, when the opening should be made into the thin membrane laterally. With a probe an effort should now be made to determine whether or not there is a communication with the subarachnoid space. If there is not the sac may be ligated at its base with chromic catgut and removed. It will be well to place a few overstitches of catgut to reinforce the closure of the pedicle. If there has been only a small opening in the vertebral column it may be necessary to do no more than suture the skin in addition to ligation of the sac. If the opening in the sac does communicate with the subarachnoid space and nerves are present in the sac they should be carefully returned to the spinal canal. In meningomyeloceles it may be necessary to dissect them free from the sac wall as well as to return the prolapsed cord itself. When the opening in the neural arch is larger, then simple ligation of the sac will not suffice. It must be removed after isolation and opening carefully down to the opening in the dura and the opening closed by suture. It will not suffice to close the skin in this case without having reënforced the closure of the dura by some form of plastic procedure. Probably the simplest way of accomplishing this is to dissect up the skin edges and then raise a flap of the fascia from either side. The fascial flap, with its base nearest the median line, is then turned over the defect and sutured while the remaining flap is sutured over the first. In this way a double thickness of fascia is utilized to protect the opening, much in the same way that imbrication of the aponeurosis of the external oblique has been utilized in the radical cure of inguinal hernia. Utliization of such fascial flaps is better than implanting foreign material, as silver wire filigrees or even than the transplantion of free fascial flaps. The propriety of operating upon myelocystoceles is a debatable question; in all events it usually fails. It is often impossible to distinguish this variety of spina bifida even after the sac has been opened, as the degenerated cord tissue in the wall of the sac cannot be recognized by the naked eye. Drainage should be avoided in operating upon spina bifida.

Certain "bugbears" are perpetuated in surgery, and one of these is the harmful, even fatal, effect of the escape of cerebrospinal fluid on opening the spinal canal. In our experience no harmful effect has ever followed its escape. The after-care of these infants is important.

The wound should be protected by a collodion dressing, primarily reënforced by a well-padded gauze dressing, which should be changed frequently, as it is difficult to keep it free from urine and feces. If possible it is better to keep the children on their abdomens. Elsberg recommends that they be strapped to previously prepared plaster-of-Paris molds.

SPINA BIFIDA OCCULTA.

Although congenital in its origin this form of spina bifida is usually not diagnosed until early adult life, and as many cases are symptomless they escape detection altogether. *X*-ray is about the only means of accurately diagnosing these defects, although their presence should be thought of if partial or complete paralysis of the bladder or rectum, disturbances in sensation in the lower extremities and tropic ulcers of foot are present. The presence of hypertrichosis in the lumbar or sacral regions should lead one always to suspect spina bifida occulta, as should a lipoma of that region. The etiology of this variety of spina bifida is obscure. The most logical explanation would seem to be that, in embryonal development, the layers of epiblast which form the skin and the neural tube, fail to divide at this particular location, so that consequently the skin, meninges and even cord itself remain adherent. Although the cord occupies the entire length of the spinal canal during fetal life, at birth the cord reaches only to the third lumbar vertebra and in the adult to the bottom of the first lumbar vertebra, so that the length of the canal increases more rapidly than the cord, with the result of, in spina bifida occulta, traction on the cord.

Diagnosis.—With what has already been said it should not be difficult to suspect the presence of spina bifida occulta. The *x*-ray alone will make the diagnosis certain. Cases are reported in which the growth of hair over a spina bifida occulta has been luxuriant. It may even be sufficiently long and of such a shape as to suggest a tail. The frequency of lipomata overlying these defects has been mentioned; other tumors as fibromata, angiomata, dermoids and myomata, growing either within or outside of the vertebral canal at or near the bony cleft, have been reported. Von Recklinghausen thinks the presence of these tumors may be explained by the growth of embryonal cells in the formation of the defect. Should such tumors grow anteriorly they will encroach onto the cord and cause pressure symptoms. Should they grow posteriorly they will be present in the back as solid tumors. Even in the absence of such growths vesical or rectal disturbances, disturbances of sensation in the lower limbs, paralytic club-foot or trophic ulcers for which there is no apparent explanation should lead one to think of spina bifida occulta.

Treatment.—In those cases causing symptoms a longitudinal incision should be made and a lipoma or other tumor, if present, removed. At the base of the tumor a tough fibrous band will usually be found

FIG. 316.—Growth of hair over the region of a spina bifida occulta. (Elsberg' of the Spinal Cord, copyright by W. B. Saunders Company.)

FIG. 317.—Skiagraph of spina bifida occulta. (Kellner.)

which should be divided, and if attached to the dura a portion of the latter may also be removed. If pain is referred to any particular nerve root it may be divided intradurally. Katzenstein, Jones, Elsberg and others report marked improvement in symptoms following such an operative procedure.

TRAUMATIC LESIONS.

These may be divided into

(*a*) Injuries which involve only the vertebra, the cord escaping.
(*b*) Injuries involving the cord without injury to the vertebra.
(*c*) Injuries in which both vertebra and cord are involved.

(*a*) Injuries which involve only the vertebra.

1. Sprains and contusions of the spine.
2. Fracture and dislocations of the vertebra.
3. Gunshot injuries.

Sprains and Contusions of the Spine.—As there are many joints and, therefore, many ligaments in the spinal column, sprains are common. They result from an overstretching of the ligaments, with a consequent tearing and cause the lame back so frequently seen in dispensary practice in laborers who lift heavy weights. In the acute stage the treatment will consist of strapping with adhesive strips or even in severe cases the application of plaster-of-Paris jackets, avoidance of further muscular effort, application of heat and stimulants to combat shock and anodynes to relieve pain. Afterward rubbing with liniments will help to relieve the condition and restore function.

Contusions of the spine are limited to the more superficial structures, resulting in swelling, as the muscles are the seat of localized hemorrhage. Little more than rest with applications of evaporating lotions, as lead water and laudanum, are necessary, and the period of disability is not so long as in sprains where ligaments are torn.

Fractures of the Vertebra.—Fractures of the vertebra may occur, though rarely, without damage to the cord. Thus a fracture of the spinous process or of the arches need not necessarily result in injury to the cord. They result from direct violence, as a rule, although fracture of the spinous processes may occur as the result of muscular action. As would be expected, fracture of the arch is much more serious than fracture of the spinous process. The same force that fractures the arch is at times sufficient to drive them forward to press on the cord. Fracture of the arch alone is said to be more common in the cervical region, while fracture of the spinous processes is more common in the dorsal region.

Dislocations of the Vertebra.—Pure dislocations of the vertebra are rare, and it is still more unusual to have the cord escape injury when dislocation occurs. Instances are reported, however, of dislocation in the cervical region which were unaccompanied by cord symptoms.

Thus Woolsey mentions a case of incomplete bilateral forward dislocation of the axis, reported by H. W. Wilson, in which the cord was not involved, as well as one of Phillips. Other instances are recorded. The cord usually is encroached upon, however, in dislocations of the vertebra, so that these injuries will be more fully discussed under the heading of injuries to the vertebra in which the cord is involved.

Gunshot Injuries.—LaGarde[1] states that fracture of the neural arches without cord involvement rarely occurs, while fracture of the centra or processes is apt to occur without cord involvement when the velocity of the bullet, whether it be a large or small caliber, is low.

(*b*) Injuries involving the cord without injury to the vertebra.

1. Concussion.
2. Contusion.
3. Hematomyelia.

Concussion.—Concussion of the cord is analogous to the similar injury to the brain. According to Mr. Makins, who made a special study of these injuries occurring during the Anglo-Boer War, they are due to "the vibratory force communicated to the cord by its underlying bony canal," and are caused by low velocity bullets whose course leads them to impact against the bony canal or near it without penetration. Makins classifies such injuries as: (1) Slight concussion; (2) severe concussion; (3) contusion; (4) hemorrhage; (5) intramedullary hemorrhage (hematomyelia). Those cases classified as *slight concussion* show transient cord symptoms. Those cases classified as *severe concussion*, however, are more serious and often exhibit symptoms of a complete transverse lesion of the cord. Here the velocity of the bullet impinging against the column, has been greater, communicating a more severe vibratory force to the cord, resulting in localized hemorrhage, and it is even possible that the cord is disorganized.

Gordon Holmes[2] classifies the injuries to the spine and spinal cord occurring during the European War as direct injuries, contusions and concussion. In speaking of those injuries coming under the head of concussion, Holmes states that the mechanism is still in doubt. Fichler's explanation is that the cord in vibrating as the result of oscillation of the vertebral column comes in contact with the vertebra and is bruised as a consequence.

For those sufficiently interested this article contains an excellent pathological description of the spinal cord changes resulting from injury to the cord. Holmes conclusions are: (1) The structural lesions in the spinal injuries of warfare are rarely sharply limited or circumscribed and cannot be compared to those produced experimentally in a physiological laboratory. The level of the lesion as indicated by the clinical symptoms, for instance, often does not correspond with the level of maximum damage. (2) The lesions are so irregular in distribution and severity when the spinal injury is not complete that much care is necessary in drawing conclusions from the clinical symptoms

[1] Gunshot Injuries, p. 207.
[2] British Med. Jour., November 20, 1915.

alone on the functions of parts which it may be assumed have been involved. (3) Secondary changes may occur later in the cord, which can alter or modify the clinical symptoms.

Contusion.—Contusion of the cord is closely allied to concussion, although Mr. Makins calls attention to certain differences. Thus in a case of contusion with necropsy reported there were adhesions of the dura to the bone at the point of injury, and the cord was completely disintegrated for several segments, and had the appearance of a "semidiffluent, yellowish material of soft consistency." The symptoms were those of a transverse lesion, resulting in death three weeks after injury.

Hemorrhage.—Hemorrhage (extra- and intradural) was found as surface extravasations. Wilfred Harris[1] reports 2 cases of intrameningeal spinal hemorrhage which were sudden in onset and due to muscular exertion. In the first case the symptoms began suddenly with pain in the lumbar region, which spread down the front of the thigh to the knees; legs became wasted and power was lost gradually. There was no loss of bladder control. The spine became immobile. These symptoms continued for sixteen months, at which time laminectomy was performed and the spines and laminæ of the twelfth thoracic and first and second lumbar vertebra were removed, uncovering a purplish mass, about five inches in length, smooth of surface and cystic in one part, the cyst containing yellow fluid.

Remault[2] and others have also reported instances of hemorrhage into the spinal meninges without trauma. The treatment of this class of injuries is largely expectant. Rest in bed, careful attention to the skin of the back and to the bladder and bowels is essential. As has been said, the hemorrhage in the slight cases is absorbed and the symptoms disappear. In the more severe cases there is disintegration of the cord substance, and, therefore, no improvement is to be expected from any plan of treatment. Experience has apparently shown that laminectomy is not followed by good results. Mr. Makins states that in his entire experience in the Anglo-Boer War he only saw 1 case that would have been the better off for laminectomy. Col. L. A. LaGarde[3] states that operative interference in war wounds of the spine has yielded poor results, and quotes Fallenfaut, who stated that in 5 laminectomies which he saw at Moukden, death occurred rapidly.

By far the more usual form of hemorrhage, however, was hematomyelia, or intramedullary hemorrhage. This form of hemorrhage accompanies severe concussion, and usually results in a disintegration of the cord substance. If the hemorrhage is small it may be absorbed as in cases of slight concussion.[4] A casé of hemorrhage extending through six thoracic segments of the cord has been reported.

Babinski[5] reports a case of a soldier suddenly paralyzed by explosion

[1] Proc. Royal Soc. Med., Neurological Section, No. 5, vol. v.
[2] Semaine médicale, July 29, 1908.
[3] Gunshot Injuries.
[4] Jumentie Reveu Neurologie, July, 1915, p. 579.
[5] Ibid.

of a shell near him. He was not hit by shell fragments and the paralysis was ascribed to a hematomyelia.

(*c*) Injuries in which both the vertebra and cord are damaged.

Fracture-dislocations.—Well over 50 per cent. of the fractures of the vertebral column are accompanied by dislocation, and in practically all instances the cord is crushed to a greater or less extent. Fracture-dislocation is more common in the cervical and lower dorsal regions. As would be expected, these injuries are more common in males, since they are usually the result of great violence. Fracture-dislocation

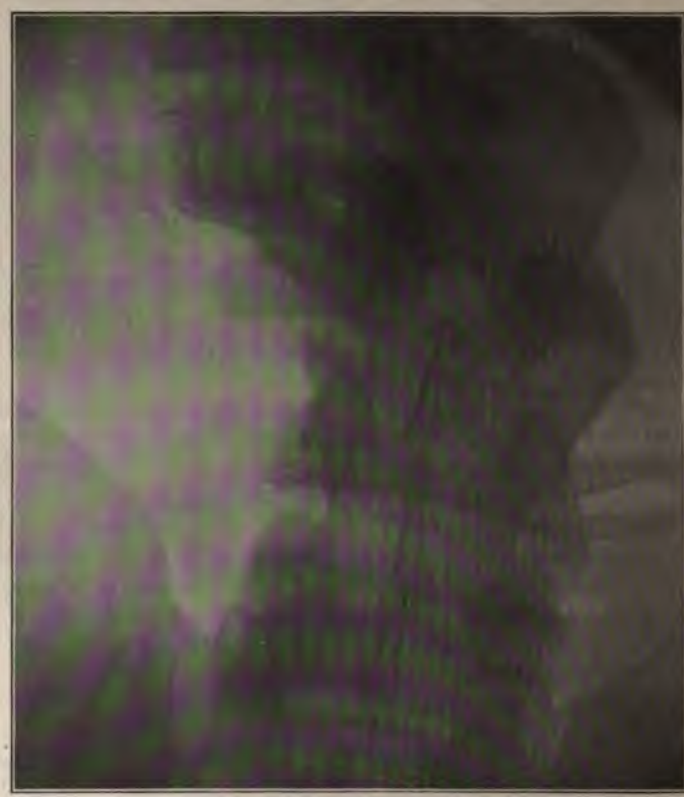

FIG. 318.—Fracture-dislocation of vertebra.

may result, however, from direct or indirect violence, and both fracture and dislocation have each been caused by muscular action. In general, fractures of the vertebra are not common, as they comprised but one-half of 1 per cent. of all fractures in Stimson's table. Fractures through the bodies of the vertebra are more common than any other type, especially as the column is followed downward. They comprise about one-half of fractures of the cervical region and three-quarters or over of fractures of the lower dorsal region. The important feature of fracture-dislocation is the damage done to the cord.

Etiology.—The exciting cause of fracture is violence, whether it be direct or indirect. The vertebral column is quite elastic because of its many joints, and more especially the intervertebral disks. It therefore can stand a marked degree of bending and even considerable rotation. Fractures result, however, when compression is too great for the spongy bodies to stand, as in violent bending of the body or falls on the back, falls lighting on the feet, etc. The usual violence then is indirect. In run-over accidents, crushes, etc., the violence is direct and applied to spines and posterior arches. The mechanism of fractures of the vertebra is somewhat complex. If the column bends violently in flexion the ligaments of the intervertebral joints are stretched. If these should rupture, dislocation will result and may or may not be permanent. There is a tendency to forward displacement of the upper vertebra in dislocation. Should the ligaments hold then tremendous compression is brought to bear on the bodies, with the result that they are crushed usually into a wedge, with consequent slipping forward of the upper vertebra. Muscular action has been mentioned as an infrequent cause of fracture. Accidents of this nature have occurred as a result of diving into shallow water, with violent twisting of the head as a result. While fracture may occur at any part of the vertebral column the fourth, fifth and sixth cervical, eleventh and twelfth dorsal and first lumbar are more frequently fractured than the others.

Symptoms.—There are two sets of symptoms: (*a*) Those due to the fracture itself, and (*b*) those due to crushing of the contents of the spinal canal. By far the more important are the latter, and, in fact, it depends entirely upon the extent of cord injury as to whether recovery of life and function will occur. To dispose of the less serious group of symptoms first, those due to the fracture itself, it is not always possible to elicit such symptoms. Usually, however, localized tenderness over the fractured vertebra, accompanied by possible swelling and ecchymosis and rarely crepitus, may be elicited. The symptoms due to crushing of the contents of the spinal canal depend altogether upon the amount of damage done. The cord is well protected by the dura, the cerebrospinal fluid in the subarachnoid space and its deep position in the center of the canal. If the cord is completely divided transversely, paralysis below the level of the lesion will be complete and permanent. If the cord be only partially destroyed there will be disturbances of motor and sensory function. Symptoms will vary according to the location. In the cervical region death rapidly ensues, preceded by a high temperature, especially if the upper cervical segments of the cord are crushed. The last case of fracture of the vertebra, which we have observed but recently, was one of this variety. In this case death occurred six hours after the accident and was preceded by a temperature of 108° F. *X*-ray showed fracture of the second and third cervical vertebra. The level of paralysis and anesthesia will entirely depend upon the segment of the cord involved, and will in no way vary from paralysis and disturbances of sensation from other

causes. Thorburn has shown that in fractures of the dorsal region the lesion is usually two vertebra higher than the nerve coming out from below the displaced vertebra. They cause paralysis of the abdominal muscles, legs, bladder and rectum. Starr has shown that fractures in the region of the last two dorsal vertebra cause anesthesia up to Poupart's ligament, and if the patient recovers the thighs remain paralyzed. In fractures in the upper part of the lumbar region paralysis may be limited to the legs below the knees, but involves the bladder and rectum. Lesions below the first lumbar involve the cauda equina and cause paralysis of the feet and peroneal loss of control of the bladder and rectum and anesthesia in saddle-shaped areas on the buttocks about the anus and on the posterior part of the genitals. Diagnosis between lesions of the cauda equina and lower segments of the cord is not always possible. Prognosis of cauda lesions is much better.

To determine the exact level it is therefore necessary to know what muscles and groups of muscles are supplied by certain segments of the cord as well as what functions are controlled by these segments. It will not be necessary, therefore, to give the reader a table of localization again here, since it has been fully set forth in a table on page 826. In complete transverse lesions the symptoms will immediately appear and will be permanent. If the cord has not been divided and the symptoms are due to hemorrhage or edema they will be slower in onset and tend to improve as the hemorrhage or edema is absorbed.

Prognosis.—Fracture-dislocations are serious injuries from both the standpoints of mortality and morbidity. Burrell[1] collected 244 cases in which the mortality was 64.5 per cent. Serlt's series, 270 cases, showed even a higher death-rate, 80 per cent. If the cord has been completely divided the prognosis is hopeless as regards recovery of function. The expectancy of life depends largely upon the level at which the cord is crushed. If it has been the cervical cord, and especially the upper segments, the patient may live only a few hours, as in the case which we have already mentioned. The lower the level of the injury the longer will the patient survive generally, and life may be dragged into months or even years, until it is terminated by sepsis from bladder and kidney infections or from bed-sores or by a general state of asthenia. Save in instances of slight or moderate concussion, spontaneous recovery does not occur, although a marked improvement in pressure symptoms may occur if the cord has only been partially destroyed at the level of injury.

Treatment.—It often requires a nicety of surgical judgment to decide whether or not to operate in recent injuries of the spinal cord. If the paralysis is immediate then the chances are all in favor of a complete transverse lesion of the cord, and laminectomy is futile. Should the paralysis be slower in onset, requiring several hours or days to fully show itself, then the chances favor hemorrhage or edema as a causative agent.

[1] Ann. Surg., October, 1905.

A. R. Allen[1] reports the results of some interesting experiments on dogs. This work was done to determine what amount of injury measured in Gram centimeters delivered by impact to the exposed cord would be followed by (*a*) spontaneous recovery, and by (*b*) recovery following operation. Any impact up to 340 g.cm. could be recovered from with normal motor function without operation. An impact of 450 g.cm. or over was followed at once by the symptoms of a transverse lesion, and the animal promptly died unless the operative procedure recommended by Allen was carried out. This consists of incising the cord in the area of injury parallel with and near to the posterior median septum. The incision should be about 1 or 2 cm. in length and made with a cataract knife. The object of incising the cord is to drain off the blood and serum at the point of injury. In experimental animals, when this was done, functional recovery has occurred, the controls either dying or remaining paralyzed. Encouraged by the results of these experiments, Allen tried the procedure in 3 cases of fracture-dislocation in human subjects. There was no effect apparently in 2 cases, but in the third marked improvement followed. This procedure seems promising to us. One would not hesitate to incise the brain, why should there be hesitation about incising the cord? The difficulty lies, however, in selecting the cases. As has been said, fracture-dislocations in the cervical region usually are rapidly fatal and are not amenable to operative procedure. Fracture-dislocation in the dorsal or lumbar region, if not fatal, are usually followed by improvement in cord symptoms after a few days, and one hesitates to operate while this improvement lasts. Of course if the *x*-ray shows pressure by bone, laminectomy is advisable. We have operated upon cases several years after injury where the *x*-ray showed pressure on the cord by either an encroachment on the canal by a dislocated vertebra or by callus, and been surprised to see marked improvement of symptoms follow. For example, four years ago one of us operated upon a young Italian who had been hurt one and a half years previously in a mine accident. Immediately after the injury he had all of the symptoms of a complete paraplegia, and his condition was but little improved at the time of operation. A little motion and sensation had returned in the lower limbs, but paralysis of the bladder and rectum was still complete. The *x*-ray showed angulation of the vertebral column at the level of the first lumbar vertebra, due to old fracture-dislocation. Laminectomy was done, the spines and laminæ of the eleventh and twelfth dorsal and the first lumbar vertebra being removed. Within a week sensation in the legs was improved and gradually control of the rectum and bladder and motion of the lower limbs returned. Six months after operation the patient walked out of the hospital without crutches, using only a cane. Many others have had similar experiences, so that, while immediate laminectomy has been disappointing, this operation has yielded brilliant results in old

[1] Jour. Nerv. and Ment. Dis., 1914, lxi, 141–147.

cases sufficiently often to encourage its performance. The rule which we follow in handling injuries to the cord is, unless *x*-ray should show definite pressure by displaced vertebral fragments, to wait during the period of improvement until indications are evident that a point has been reached beyond which spontaneous recovery is unlikely. Then laminectomy is advisable. The expectant treatment consists of rest on an air mattress and careful attention to the skin of the back, bowels and bladder, with plenty of nourishing food to build up the general resistance of the patient. Decubitus will occur in spite of careful nursing at times, but it also can often be prevented. As to the results of operation, De Juervain's table shows of 218 cases submitted to operation, 13.8 per cent. were cured, 22 per cent. were improved, 37.2 per cent. were unimproved, 18 per cent. made worse and 25.2 per cent. died from operation. Floyd has shown that of 185 operations for fracture of the spine the mortality was 50 per cent., 34.6 per cent. were improved. In 82 cases the operation was done shortly after the injury; of these 72.2 per cent. died and 20.7 per cent. recovered or were improved. Thorburn reports 56 operative cases, with a mortality of 67.8 per cent. It is probable that the mortality has been lessened somewhat, as the technic of laminectomy has been improved in recent years, and more judgment is undoubtedly shown in the selection of cases. A large percentage of those who died formerly were instances of complete transverse lesion of the cord which should not have been operated upon. An interesting field of work may be opened up in anastomosing spinal nerve roots. Spiller[1] states the reported cases are not as yet sufficiently numerous to afford convincing proof that regeneration with return of function really occurs. Kilvington has employed this method on dogs, and in one case at his suggestion it was attempted on a man but was not successful. Frazier and Mills[2] report a case in which a motor root above was anastomosed with a motor and sensory root below, and they considered the operation successful. It was performed for the relief of incontinence of the bladder. Eight months after the operation the man stated that he could dispense with the urinal, which he had hitherto worn constantly, for a period of twelve hours, and that with the assistance of pressure over the suprapubic region, partial evacuation of the bladder was possible. The man was able to retain the urine for two and a half hours at a time.

Dislocations of the Vertebra.—Stimson[3] describes dislocation of the vertebra as an injury in which the adjoining articular processes on both sides have been partly or completely separated from each other, with or without avulsion of portion of the body of either vertebra or fracture of one or more processes. Diastasis he describes as those dislocations in which the intervertebral disks and other ligaments having been torn, the vertebra are longitudionally separated from each

[1] Prog. Med., September, 1913, p. 280.
[2] Jour. Am. Med. Assn., December 21, 1912.
[3] Fractures and Dislocations.

other in front or behind, but have not also been so horizontally displaced that the articular surfaces on either side have been put out of line with each other. In comparison with fractures, dislocations are not so common, and yet Blasius, in 1869, collected 294 cases. Of these 185 were dislocations, 37 diastases and 72 were unclassified. By far the most common seat is the cervical region. Next in frequency is the dorsal region, then lastly the lumbar, in which dislocation is exceedingly rare. To this collection of cases Porta contributed the largest number observed by a single surgeon, his cases numbering 27.

Mechanism.—As in fractures the exciting cause of dislocations of the vertebra is indirect violence, usually the result of hyperflexion of the column. They may occur, however, by abduction or rotation and occasionally by extension. Stimson classifies dislocations of the spine as follows:

Dislocations by flexion, ventral or dorsal.
  Bilateral forward.
  Bilateral backward.
Dislocations by abduction or rotation.
  Unilateral forward
  Unilateral backward } complete or incomplete.
  Bilateral in opposite directions.
  Transverse (?)

Associated lesions comprise rupture of various ligaments muscles, bloodvessels and nerves, fracture of the bones and injuries of the spinal cord and its membranes and those later changes which may be induced by the primary ones. The intervertebral disk is always ruptured or torn away from one or the other vertebra, and this rupture or separation is almost invariably complete and is accompanied by the avulsion of larger or smaller fragments of the bone. In one or two cases the disk appears to have been crushed. The capsular ligament on one or both sides, according to the character of the displacement, is always torn. The anterior and posterior ligaments are either torn wholly or in part or stripped from their attachments to the bodies of the vertebræ, sometimes bringing with them in the latter case portions of the bone. The ligaments between the laminæ and the spinous processes are either torn or put upon the stretch and those between the transverse processes were torn in the only reported case found by Blasius in which their condition was mentioned. Instead of rupture of the ligaments, fracture of the processes to which they are attached may occur and various other fractures of the adjoining processes or of more distant parts are frequently observed. The muscles surrounding and attached veins coming from the bodies of the vertebra or nerve trunks at their point of emergence through the intervertebral foramina may be torn. As in fractures of the vertebra, by far the most important feature is injury to the spinal cord. Stimson states that Blasius summarizes this phase of the subject as follows: In no form of dislocation is injury of the spinal cord a necessary consequence; such injury is less to be expected in unilateral dislocation, and in unilateral dislocation forward

of the cervical vertebæ it is always, or almost always, only a simple compression without crushing; in bilateral dislocation backward or forward either of the dorsal or cervical vertebræ, the cord is exposed to more serious lesions and seldom escapes entirely uninjured, and when the displacement is forward the cord is mechanically affected in most cases, but the cases of severe injury are fewer than those in which all injury is escaped; finally the danger is least in bilateral dislocation in opposite directions.

The danger to the cord is greatest in dislocations of the cervical regions, especially of the lower cervical vertebra, the fifth and sixth being most frequently involved.

Diagnosis.—The symptoms of dislocation of the vertebra are similar to those of fracture. They may be divided into (*a*) those due to the lesion itself, and (*b*) those due to pressure upon the cord. A history of violence will be obtained in all cases. The symptoms due to the lesion itself will be deformity, which is either obvious or may be detected by palpation, localized pain, usually accompanied by muscular rigidity. A change in the relation of the transverse processes to each other and dislocations being by far more common in the cervical region the attitude of the neck is more or less characteristic. As in fracture the more important set of symptoms are those due to pressure on the cord. Partial or complete paralysis below the level of the lesion is the most important of this group, other symptoms depending upon the level of the lesion. As has been said in discussing fractures of the vertebra, injury to the cord in the higher cervical segments is rapidly fatal, so that this would apply to dislocations of the atlas and axis if the cord were involved. Disturbances of the sympathetic system, especially the vasomotor system, have been pointed out by Hutchinson.[1] Sudden rises in temperature, pallor, slowing of pulse-rate, without the intermission so commonly seen in injury to the brain, may be present. Priapism may be present if there is a paraplegia due to injury to the lower cervical, upper or mid-dorsal regions. Cystitis may develop unless scrupulous care is used in treating the paralyzed bladder, and may result in an ascending infection of the kidneys. Decubitus is also prone to occur.

Prognosis.—That dislocation of the vertebra is a serious lesion is evidenced by the statistics of Blasius. Of 159 cases in which the diagnosis was certain, 36 recovered and 123 died, a mortality of 77 per cent. In the 36 cases which recovered the dislocation was completely reduced in 27 and partially reduced in 2. All of the 29 cases in this group were dislocations in the cervical region. It is interesting to note that 5 of the remaining cases which recovered were also in the cervical region. The promptness with which death occurs depends largely upon whether the cord is partially or completely divided or simply pressed upon. In those cases in which the cord is crushed and either partially or completely divided, death takes place quickly,

[1] London Hospital Report, 1866, iii, 357.

usually within a week. Thus of the 123 cases in Blasius's series death occurred in one week in over one-half of this number. Life for months is not incompatible with pressure, especially if the lower segments of the cord are the ones involved.

Treatment.—As in other dislocations the first object is reduction, if this is possible. The earlier the attempt at reduction is made the greater are the chances of success, and, in fact, the very urgency of the symptoms will demand rapid action on the part of the surgeon, especially in the cervical region. The patient's family or friends should be advised that an attempt at reduction may be followed by sudden death. Generally under an anesthetic reduction may be attempted by extension and counterextension. With the patient in the face-down posture, the operator, standing at the patient's head grasping the head and neck, makes extension while an assistant pulls on the feet, thus making counterextension. The dislocated vertebra will slip back with a snap and disappearance of the deformity will be further evidence that reduction has been accomplished. The symptoms will almost immediately disappear, or at least disappear rapidly. An interesting case is one reported by Wallace and Bruce.[1] The patient, a man, turned his head quickly and in doing so felt his neck give a little crick. At the moment there was no pain or other inconvenience. Shortly afterward he felt a lump in the back of his neck, and when he attempted to stoop he found his head was fixed and that the attempt to move it forward was very painful. He could not move his head to either side, but could move it slightly forward. He could use his arms and legs well. A physician diagnosed rheumatism of the neck. He remained on a ship for two months after the accident without working. He now had considerable pain in the back of the head, probably in the distribution of the great occipital nerves. He had pain in the left shoulder and in the calf of the leg. The *x*-ray showed a dislocation of the upper part of the spine, between axis and atlas. The atlas had slipped forward on the axis and it was also inclined obliquely. The displacement was so great that it is difficult to understand how the cord could have escaped compression. A little over five months after the accident the patient's small son, in play, caught hold of a shawl about his father's shoulders and tried to pull it away. In doing so he apparently jerked the neck sideways. This caused a sudden severe pain in the neck. The patient was unable to lie down in bed that night on account of the pain in the back of the head. The following day he felt some weakness of the fingers of both hands, and this weakness gradually spread up the arms and down the legs. Retention of urine developed and the limbs became almost completely paralyzed. The patient's condition became so critical that it was decided that he had not many hours to live unless he could be relieved by reduction of the dislocation. He was raised slightly in bed and a long towel was placed behind the lower part of his neck and used to make traction

[1] Rev. Neurol. and Psychiat., January, 1910; Abstract, Prog. Med., September, 1910, p. 311.

upon it in a forward direction. The operator stood behind the top of the bed and placed his hands below the jaws, making firm traction upward and backward. Almost immediately the head was felt to slip into place, and at the same time the lump disappeared. The patient felt greatly relieved almost immediately after the replacement, and the diaphragm resumed its functions. The recovery was gradual and almost perfect.

After reduction it is not necessary to advise anything more than rest in bed, as a rule. If the dislocation cannot be reduced then it will be necessary to use some form of immobilization apparatus, such as a well-padded posterior splint if the dislocation be in the dorsal or lumbar region. A molded splint of gypsum or light plaster-of-Paris may be used in the case of dislocation in the cervical region.

Gunshot Injuries to the Spine.—This class of injury has already been referred to under the heading of injuries involving the cord without injury to the vertebra. Attention has been called to the work of Mr. (now Sir) George Makins in the Anglo-Boer War on contusion, concussion and hemorrhage of the cord, and later to that of Gordon Holmes growing out of the European War. It now remains to discuss those injuries in which the vertebræ as well as the cord are injured. These are the so-called direct injuries in which fragments of bone are driven directly into the spinal canal to press on the cord. These injuries differ only in the manner of production from fractures of the vertebra seen in civil life, and will present the same symptoms, depending upon the level of the injury. There is the initial shock of the injury with almost immediate paralysis below the level of the lesion. The same trophic disturbances, loss of control of bladder and rectum, priapism, etc., as in fracture-dislocation, are seen.

Riddoch,[1] in an article on "The Reflex Functions of the Completed Divided Spinal Cord in Man Compared with Those Associated with Less Severe Lesions," and Head and Riddoch,[2] in an article on the "Automatic Bladder, Excessive Sweating and Some Other Reflex Conditions in Gross Injuries of the Spinal Cord," have produced new conclusions as the result of observations on spinal-cord injuries occurring during the World War. Their work is so important that anyone interested in such injuries should read these articles in the original. Riddoch has shown that when the spinal cord is completely divided that the patient enters into the first stage or that of "spinal shock." This stage may last for several weeks, the average being about three weeks. During this stage there is complete flaccid paralysis below the level of the lesion, complete loss of sensation, absolute loss of reflexes, complete loss of bladder and rectal control. This stage is followed by the second phase or stage of the "mass reflex," which may last weeks, months or even indefinitely as shown by Cadwalader in studying a case which will be mentioned more in detail below. In the stage of "mass reflex" the paralysis changes from the flaccid type

[1] Brain, 1917, vol. xl. [2] Ibid.

to a more spastic one, reflexes return and, in fact, are usually exaggerated and the "automatic bladder" is established. The latter phenomenon is one of the most interesting of this phase. The bladder will "fire off" and complete evacuation take place when its contents have reached a certain amount, for example, 350 c.c., although this figure will vary with different patients. So it is quite possible for the patient to live in reasonable comfort in this stage of "mass reflex" if he has escaped the dangers of infection incident to catheterization, etc., of the first stage. Although, as has been said, the stage of "mass reflex" may last indefinitely, it usually terminates in a few months in the third or final stage of diminishing reflexes, usually brought about by infection of bladder or kidneys or other intercurrent disease. In this stage the reflexes gradually disappear, the paralysis changes from a spastic to a flaccid type, fever is present and the patient will die of exhaustion. Cadwalader[1] reports the results of the study of a case of gunshot wound of the spinal cord at the tenth thoracic segment resulting in complete division of the cord at this level nineteen years prior to his study of the case. At the time of the injury the cord was sutured by the late Dr. F. T. Stewart and reported in the *Annals of Surgery* by Harte and Stewart as a case of successful suture, a certain amount of return of function having taken place. Cadwalader clearly shows that no real regeneration has occurred and that the patient has simply continued in the stage of "mass reflex" having established the "automatic bladder." In the light of this report a false impression that the suture of the cord itself was successful has been cleared up and the fixed belief that the spinal cord does not regenerate after injury still stands.

Diagnosis.—The diagnosis, therefore, will be based upon the history and the presence of the above-mentioned symptoms in conjunction with *x*-ray findings.

Prognosis.—The prognosis in no way differs from that of fracture, with cord involvement due to other causes. It is not very hopeful at best, and is especially bad in this class of direct injury where the cord is completely or partially divided by the shell itself or bone fragment. The higher the level of the lesion the worse the prognosis, so that cervical and dorsal lesions are the most fatal. La Garde states that hemorrhage in various forms, intradural, extradural and hematomyelia, meningitis, myelitis, cystitis, pyelitis, surgical kidney, extreme decubitus and septicemia all figure among the causes of death.

Treatment.—Colonel La Garde, in his book *Gunshot Injuries*, tells us "operative interference in war wounds of the spine has yielded poor results." Now that the transmission of energy from the projectiles of the high-power military rifles is known to be a definite factor in producing complete transverse lesion in which concussion, contusion without pressure and hematomyelia play the principle rôle, the futility of performing laminectomy, except for very definite reasons, is at once

[1] Ann. Surgery, June, 1920, vol. lxxi, No. 6.

apparent. In recent wars those subjected to the knife have died, as a rule. Possibly the operation did not hasten the end, but we know that in the large majority of the cases no operation was indicated. Fallenfant informs us that in five laminectomies which he saw at Moukden death occurred rapidly. He saw no secondary operations. The experience of the British surgeons in the Anglo-Boer War was no better. There were no laminectomies following the battle of Santiago, as nearly all the cases in which the cord was seriously involved with

FIG. 319.—Gunshot injury of spinal cord. No. 38 caliber bullet lying in spinal cord at level of fifth cervical vertebra. Cord completely divided at the level.

fracture, died before reaching hospitals or soon thereafter. In the light of our present knowledge an operation such as a formal laminectomy is only indicated when symptoms of irritation and compression from spicules of bone or a lodged missile may be indicated by the history and *x*-ray evidence as well. Surgeons are often tempted to perform exploratory operations in gunshot injury of the spine, and yet Mr. Makins informs us that he saw but one case in his whole series in which it seemed possible to regret the omission of an exploration. The European War has apparently not changed the attitude of army

surgeons in general to any extent in regard to gunshot injuries of the spine. One reads, however, that in practised hands, operative treatment should not add materially to the risk,[1] and that when any doubt exists the patient should have the benefit of an exploratory operation.[2] Lieut.-Col. Sargeant states, further, that exploratory operation is not a difficult or dangerous procedure, that it would reveal conditions not recognizable by neurological methods or *x*-ray. The chief difficulty in recent cases was sepsis, which was often a deterrent factor. So far as we have been able to find out by a review of the literature there

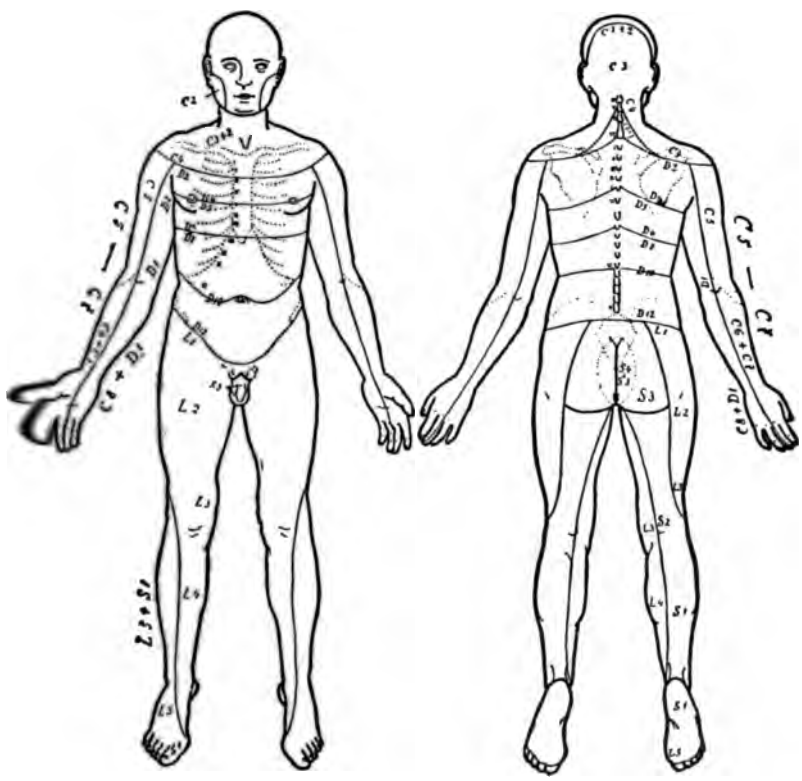

FIG. 320.—Diagram showing sensory supply of the spinal cord segments. (Seiffer.)

have been no statistics published to shows the results of a series of laminectomies for gunshot injuries of the spine occurring in the European War. The treatment of such injuries, therefore, is largely expectant. Rest on an air mattress, careful attention to the skin of the back and to the bladder and rectum are essential. Other than attention to these details symptomatic treatment is all that can be done. One of us (Dr. J. S. Rodman) has operated upon an interesting case of gunshot injury of the cord. The patient, a colored man, aged

[1] Amour: British Med. Jour., March 25, 1916.
[2] Sergeant: Ibid.

thirty-eight years, in attempting to act as peacemaker, was shot with a 38-caliber revolver, the bullet entering the right side of the neck, coursing upward and lodging, as the *x*-ray figure 319, p. 848, will show, opposite the fifth cervical vertebra. There were symptoms indicative of lesion of the fourth and fifth cervical segment, and as the patient's condition seemed sufficiently good to warrant operation, laminectomy was done twelve hours after the accident. The spines and laminæ of the fifth, sixth and seventh cervical vertebræ were removed. The fifth vertebra was fractured and the bullet found embedded in the cord substance at this level. The cord substance was divided almost completely. The bullet was easily removed and the wound closed. The patient seemed to stand the operation well but died eighteen hours later, with all the symptoms of complete division of the cord in the cervical region.

TUMORS OF VERTEBRA.

The most common tumors affecting the vertebræ are carcinoma and sarcoma.

Sarcoma.—Sarcoma is said to be common in the vertebræ,[1] although our own experience would indicate that carcinoma was more so. Sarcoma occurs more frequently in the lower part of the vertebral column, often involves nerve roots, and is, therefore, painful. There may be a single sarcoma or several within the vertebra. Sarcoma of a vertebra may be primary or secondary. It is usually osteosarcoma, although other varieties as lymphosarcoma occur. The tumor may involve the dura or cauda equina secondarily.

Carcinoma.—Carcinoma of the vertebra is practically always secondary and metastatic to carcinoma of the breast, stomach, uterus, prostate and thyroid. In our own experience the breast has most often been the seat of the primary growth. In fact, so often has this occurred that one of us[2] expressed the opinion in the annual oration on surgery delivered October 6, 1913, to the Philadelphia Academy of Surgery, that to the bones, particularly the sternum, vertebræ and long bones, belongs "the melancholy distinction of first place in metastasis from carcinoma of the breast." The growth destroys the body of the vertebra, as a rule, and therefore should there be several vertebræ affected the column collapses and deformity results. There is usually considerable pain associated with involvement of the vertebræ, since the nerve roots are involved either by pressure or direct extension of the growths. The pain is usually of rheumatic type; in fact, there is nothing that one more dreads to hear than that one of his patients is suffering from "rheumatism" following an operation for malignant disease. Pressure on the nerve roots gives rise to the symptom-complex known as paraplegia dolorosa.

[1] Woolsey: Keen's Surg., vol. ii.
[2] W. L. Rodman: Ann. Surg., January, 1914.

Diagnosis.—The diagnosis of either sarcoma or carcinoma of the vertebra will depend upon the history of the case, distribution of pain and *x*-ray. A well-taken skiagram will show the disease (Figs. 321 and 322). The prognosis is hopeless, although in the case of sarcoma Coley's fluid and *x*-ray treatment may be tried. Sectioning of the posterior roots may be done to relieve the pain, which is at times unbearable in this condition. We have performed this operation in one case with

FIG. 321.—Carcinoma of vertebra.

fairly satisfactory results. At least four to six roots should be cut. Sectioning of the antero-lateral column may also be done if pain is unbearable. For further discussion of these procedures see section on Technic.

Other forms of malignant tumors affecting the vertebræ are myeloma and lymphosarcoma. Both forms are rare in the vertebræ. Myelomata arise in the medulla and destroy the bone as they grow.

gn tumors of the vertebræ are chondroma, myxoma, osteo[illegible]a, hondroma and exostoses.

FIG. 322.—Carcinoma of vertebra.

THE LOCALIZATION OF SPINAL LESIONS.

The exact level at which a lesion of the cord producing symptoms may be found should be decided by a competent neurologist. We believe that it is well for the surgeon to acquire as thorough working knowledge of neuro-anatomy, physiology and pathology as is possible, but that the neurologist should always be called in to decide finally the exact localization. Our own experience has been that few mistakes are made and that competent neurologists are wonderfully accurate in determining the seat of the lesion. For example, in one of our cases of extradural tumor, a patient referred to one of us (J. S. Rodman) by Dr. T. H. Weisenberg, the latter stated that we should find the

lesion at the level of the fourth or fifth lumbar vertebra. Laminectomy revealed an extradural fibroma at the level of the fourth lumbar vertebra. The symptoms upon which localization is based may be divided into (*a*) those due to pressure upon the cord, and (*b*) those due to involvement of the spinal nerve roots.

(*a*) Symptoms due to pressure upon or destruction of the spinal cord vary with the segment or segments involved. In determining the level of a lesion it is therefore necessary to know (1) the muscles or groups of muscles supplied by each segment of the cord, and (2) the sensory supply of the spinal cord segments.

It is convenient to use tables or diagrams for these purposes, and many useful ones have been prepared (Kocher, Edinger, Starr, Seiffer, Flatau and others). The one that we have adopted to show muscle supply is that of Flatau modified by Elsberg.

The Segmentary Localization of the Muscles.

A. Muscles of the Head and Trunk.

1. Muscles of the Back.

Trapezius	C 2-4	Rotation of scapula, raises shoulder, moves head to side.
Latissimus dorsi	C 6-8	Adducts and rotates arm inward, draws arm backward, raises rib.
Rhomboid	C 4-5	Rotates and moves scapula backward.
Levator anguli scapulæ	C 3-5	Raises angle of scapula.
Serratus posticus superior	D 1-4	Respiration.
Splenius capitis	C 2-8 (?)	Rotates head and draws it to side.
Paravertebral muscles	C 1-S_3	Movements of vertebral column.
Rectus capitis major	C 1-2	Rotate head and draw it back.
Rectus capitis minor	C 1	
Obliquus capitis superior	C 1	Rotate head and draw it back.
Obliquus capitis inferior	C 2	

2. Muscles of Neck, Chest and Abdomen.

Muscles of the Neck.

Platysma	C 3	Depresses lower lips and angle of mouth, wrinkles skin of neck.
Sternomastoid	C 2-3	Rotates and draws head to shoulder muscle of inspiration.
Sternohyoid	C 1-3	Depress larynx and hyoid bone, control movements of thyroid cartilage.
Omohyoid	C 1-3	
Sternothyroid	C 1-4	
Thyreohyoid	C 1-2	
Longus colli	C 2-8	Flex and rotate cervical vertebral column.
Longus capitis	C 1-4	
Rectus capitis anticus	C 1	Flexes and rotates head.
Scalenus anticus	C 4-7	Raise ribs for inspiration.
Scalenus medius	C 2-8	
Scalenus posticus	C 5-8	

Muscles of the Chest.

Pectoralis major	C 5-6	Adduction, downward and forward movement of arm.
Pectoralis minor	C 7-8 (D1)	
Subclavius	C 5-6	Depresses shoulder.
Serratus anticus	C 5-7	Fixes scapula.
Levatores costarum	C 8-D 11	Fix ribs.
Intercostals	D 2-11	Inspiration.
Triangularis sterni	D 3-4	Expiration.
Diaphragm	C 3-5	Respiration.

MUSCLES OF ABDOMEN.

Rectus abdominis	D 5–12	Constrict cavity of abdomen, assist expiration, rotate trunk, move pelvis.
Pyramidalis	D 12–L 1	
Obliquus externus	D 5–12	
Obliquus internus	D 8–L 1	
Transversalis	D 7–L 1	
Quadratus lumborum	D 11–L 2 or L 1–4	Moves pelvis and trunk, inspiration
Coccygeus	S 3–5, C	Supports coccyx.

B. Muscles of the Extremities.

1. Muscles of the Upper Extremities.

(*a*) Shoulder:

Deltoid	C 5–6	Abduct arm to horizontal, abduct and rotate arm outward.
Supraspinatus	C 5	
Infraspinatus	C 5–6	
Teres minor	C 5	Rotates arm outward.
Teres major	C (5), 6, (7)	Rotates arm inward.
Subscapularis	C 5–6	Rotates arm inward.

(*b*) Arm:

Biceps	C 5–6	Flexes and supinates forearm.
Coracobrachialis	C 6–7	Adducts forearm.
Brachialis anticus	C 5–6	Flexes forearm.
Triceps	C 6–7 (8)	Extends forearm.
Subanconeus	C 7 (8)	Fixation of synovial membrane.

(*c*) Forearm:

Pronator radii teres	C 6–7	Pronates forearm.
Flexor carpi radialis	C 6–7	Flexes and radially flexes hand.
Palmaris longus	C (7), 8, (D 1)	Flexes hand.
Flexor carpi ulnaris	C (7), 8, (D 1)	Flexes and ulnar flexes hand.
Flexor sublimis digitorum	C 7–8, D 1	Flexes middle phalanges, two to five fingers.
Flexor profundus digitorum	C 7–8, D 1	Flexes last phalanges, two to five fingers.
Flexor longus pollicis	C 6–7	Flexes last phalanx of thumb.
Pronator quadratus	6C–8, D 1	Pronates forearm.
Supinator longus	C 5–6	Flexes forearm.
Extensor carpi radialis	C (5), 6–7	Extends radially, flexes hand.
Extensor communis digitorum	C 6–8	Extension of first phalanges, two to five fingers.
Extensor minimi digiti	C (6), 7–8	Extension of first phalanx of little finger.
Extensor carpi ulnaris	C (6), 7–8	Extension and ulnar flexion of hand.
Supinator brevis	C 5–7	Supinates forearm.
Abductor longus pollicis	C 6–7	Abducts first metacarpal.
Extensor brevis pollicis	C 6–7	Extension of first phalanx of thumb.
Extensor longus pollicis	C 6–7, (8)	Abducts first metacarpal; extension of last phalanx of thumb.
Extensor proprius indicis	C 6–8	Extension of first phalanx of index finger.

(*d*) Hand:

Abductor brevis pollicis	C 6–7	Abducts first metacarpal.
Flexor brevis pollicis	C 6–7	Flexes first phalanx of thumb.
Opponens policis	C 6–7	Opposition of first metacarpal.
Abductor pollicis	C 6–7	Adducts first metacarpal.
Abductor minimi digiti	C 8, D 1	Abducts little finger.
Flexor brevis minimi digiti	C (7), 8, (D 1)	Abducts and flexes little finger.
Opponens minimi digiti	C (7), 8, (D 1)	Draws forward fifth metacarpal.
Lumbricales	C 7–8, (D 1)	Abduct and adduct fingers.
Interossei	C 7–8, (D 1)	Extension of second and third phalanges.

2. MUSCLES OF THE LOWER EXTREMITIES.

(*a*) Hip:		
Iliacus	L 2–4	Flexion at hip.
Psoas major	(D 12), L 1–3, (4)	Flexion at hip.
Psoas minor	(D 12), L 1–3, (4)	
Gluteus maximus	(L 4), 5, S 1, (2)	Extension of thigh.
Tensor fasciæ latæ	L 4–5	Flexion of thigh.
Gluteus medius	L 4–5, S 1	Abduction and internal rotation of thigh.
Gluteus minimus	L 4–5, S 1	
Pyriformis	S 1–2	External rotation of thigh.
Obturator internus	L 5, S 1–2	External rotation of thigh.
Quadratus femoris	L 4–5, S 1	
(*b*) Thigh:		
Sartorius	L 2–3	Internal rotation of leg.
Rectus femoris	L 2–4	Extension of leg.
Vastus medius	L 2–3	
Vastus internus	L 2–4	
Vastus externus	L 3–4	
Pectineus	L 2–3	Adduct thigh.
Adductor longus	L 2–3	
Gracilis	L 2–4	
Adductor brevis	L 2–4	
Adductor magnus	L 3–4	
Obturator externus	L 3–4	Adduction and external rotation of thigh.
Biceps	L (4), 5, S 1–2	Flex leg.
Semitendinosus	L 4–5, S 1	
Semimembranosus	L 4–5, S 1	
(*c*) Leg:		
Tibialis anticus	L 4, (5)	Dorsal flexion and supination of foot.
Extensor longus digitorum	L 4–5, S 1	Extension of toes.
Peroneus tertius	L 5 (S 1)	Dorsal flexion and pronation of foot.
Extensor longus pollicis	L 4–5 (S 1)	Extension of large toe.
Peroneus longus	L 5, S 1	Dorsal flexion and pronation of foot.
Peroneus brevis	L 5, S 1	
Gastrocnemius	L (4), 5, S 1–2	Plantar flexion of foot.
Soleus	L (4), 5, S 1, (2)	
Plantaris	L 4–5, S 1	
Popliteus	L 4–5, S 1	Flexion of leg.
Tibialis posticus	L 5, S 1 (2)	Adduction of foot.
Flexor longus digitorum	L 5, S 1–2	Flexion of last phalanges two to five.
Flexor longus pollicis	L 5, S 1–2	Flexion of last phalanx of large toe.
(*d*) Foot:		
Extensor brevis pollicis	L 4–5, (S 1)	Extension of large toe.
Extensor brevis digitorum	L 4–5, S 1	Extension of toes.
Abductor pollicis	L 5–S 1	Movement of toes.
Flexor brevis pollicis	L 5–S 1	
Adductor pollicis	S 1–2	
Abductor minimi digiti	S 1–2	
Opponens minimi digiti	S 1–2	
Flexor brevis digitorum	L 5–S 2	
Lumbricales	S 1–2	
Interossei	S 1–2	

The sensory supply of the spinal cord segments is well shown in the diagram of Seiffer.[1]

[1] Keen's Surgery, ii, 841.

(*b*) Symptoms due to involvement of the spinal nerve roots.

These symptoms are very important, as they are often the first to appear and may persist for months or even years before cord symptoms proper become evident. The posterior roots are generally the ones involved, so that pain and disturbances of sensation, such as paresthesia and hyperesthesia, are complained of. The pain of posterior root irritation is variable in intensity at first and much like neuralgia, to become later more localized, deep and boring in character. In fact, mistaken diagnosis of rheumatism, lumbago, sciatica and even angina have been made when the real trouble was due to irritation of a posterior root by a tumor of the cord or of the vertebræ. These root pains are unilateral at first to later become bilateral. They are made worse by jar or movements of the body, and are often accompanied by muscular spasm.

LOCALIZATION AT VARIOUS SPINAL CORD LEVELS.

BY THEODORE H. WEISENBERG, M.D.

An inflammation or myelitis of the whole spinal cord or severance of the cord will cause loss of all motor and sensory functions below the level of the lesion, with loss of all reflexes and of bladder, rectal and sexual functions. If the lesion, however, is incomplete, power is partially lost, the limbs instead of being flaccid are spastic, the reflexes are increased and there is generally present the Babinski phenomenon on one or both sides. There is no variation in this rule in spite of the literature which has accumulated, especially during the war. One fact remains, that is, a complete severence of the cord will always give a total loss of function below the level of the lesion, and if there is any variation from this, it can be taken for granted that the lesion is incomplete.

When surgical procedure is considered it is important to recognize, if possible, how much of the cord is destroyed, whether this be the result of a bullet, crush injury or of tumor.

For example, recently I saw a man in whom there was a history of a crush injury in the middle back. The patient immediately became paralyzed in both lower limbs, there being total loss of motor sensation and of bladder and rectal functions. My examination showed that both limbs were flaccid, all tendon and skin reflexes were lost in the lower limbs and sensation was lost over both lower limbs and lower abdomen to a point corresponding to the line of the umbilicus. As is well known, this line corresponds to about the level of the ninth and tenth thoracic segments. These symptoms indicated that there was a complete crush injury of the spinal cord at the level of the ninth and tenth thoracic segments. The important point to be determined in this case was—and this must be established in every case—did this lesion destroy the whole extent of the cord below the point of the injury or were only certain segments destroyed? If the former were true it

is at once evident that surgical interference would have been out of the question.

Examination of the muscle reflexes showed at once that by tapping the muscles in any portion of the legs and thighs a response could be obtained, but no response was possible by tapping the muscles in the lower abdomen. This indicated that the injury involved only the ninth, tenth, eleventh and twelfth thoracic segments, and that the segments below were not implicated. Operation confirmed this opinion.

It is therefore necessary to appreciate the importance of muscle reflexes. By a muscle reflex is meant the response of a muscle when irritated by a percussion hammer. If the cell groups corresponding to the muscles are destroyed no response will be obtained. If there is a response it can at once be assumed that the corresponding cells in the spinal cord are normal. These muscle reflexes are most important in the diagnosis of spinal cord lesions and are far more important than the so-called reflexes of defence. A study of these muscle reflexes was made by me and published in the *Journal of Nervous and Mental Disease*, September, 1916.

It is important, in making a diagnosis of spinal cord lesions, to indicate to the surgeon the exact localization of the lesion. If it is dural and causes a general pressure upon the cord certain symptoms will be apparent. If in the anterior part the symptoms will be motor and there will be a limited loss of power and interference with the muscle, tendon and electrical responses, followed by atrophy. If the pressure is on the posterior part of the cord there will always be, first of all pain, this being referred to the distribution of the involved roots. Following this there should be disturbance of sensation, and it is this disturbance of sensation which gives a very accurate knowledge of the location of the pressure. Further growth of the lesion must cause involvement of the motor columns no matter from what point the pressure appears, this causing weakness and spasticity of the limbs, with increased reflexes and the Babinski phenomenon. Still further growth will cause greater motor and sensory loss, with interference with bladder, rectal and sexual functions. Finally a complete severence of the cord must cause loss of all functions below the site of the lesion.

It is also important to remember that the spinal roots have a certain extradural course before their exit. Take, for example, the second lumbar root, which has its exit below the second lumbar vertebra. The intradural course of this root is about three inches. It is impossible, from the neurological standpoint, to diagnose what part of the root is implicated. Therefore it is necessary to expose the whole intradural course. As a general rule the tumors are higher than the symptoms indicate.

It is not difficult to remember the intradural course of the roots. In the upper cervical region the roots have almost a direct exit, increasing in their intradural course gradually. All the thoracic, lumbar and sacral roots have their exit at the bottom of their corresponding vertebræ. For example the second lumbar at the bottom of the second

lumbar vertebra and the third lumbar at the bottom of the third lumbar vertebra. The cervical roots, however, are different because there are eight cervical segments and only seven cervical vertebræ. Therefore in the cervical region the rule is different, the roots having their exits at the top of their corresponding vertebræ. For example the eighth cervical segment has its exit at the bottom of the seventh or the top of the first dorsal, the seventh has its exit at the top of the seventh, the first has its exit at the top of the first and so on.

For the sake of clearness a portion of each part of the cord will be selected for examples of the results of lesions.

Cervical Cord Lesion of the Eighth Cervical and First Thoracic.—*Motor Symptoms.*—The cells of the anterior horn and the roots coming from these two segments supply the small muscles of the hand, therefore a sudden lesion will produce loss of power in the muscles of the hand to be followed by a gradual atrophy and electrical reactions of degeneration. If the lesion is complete, all motion and sensation is lost below. If incomplete because of the implication of the crossed pyramidal tracts, there will be weakness in both lower limbs with a spastic condition, increased reflexes and Babinski phenomenon. If the lesion is unilateral, as in the Brown-Séquard syndrome, these symptoms of course will be only on the side of the lesion. Muscle reflexes will be interferred with in the small muscles of the hand.

Sensory Symptoms.—The posterior roots which enter the eighth cervical and first thoracic are in relation with the root areas in the under part of the hand, forearm and arm, therefore there will be a disturbance of all forms of sensation in these parts. If the lesion is complete all sensation is lost below this area. If the lesion is of the Brown-Séquard type there will be the root disturbance mentioned, with a disturbance of sensation for touch and muscle sense in the chest, abdomen and lower limb on the same side, with disturbance of pain and temperature sensations in the chest, abdomen and lower limb of the opposite side.

Lesion in the Ninth and Tenth Thoracic Segments.—*Motor Symptoms.*—The cells of the anterior horn and roots coming from them supply the muscles in the lower abdomen, that is, the abdominal muscles below the umbilicus. Therefore a sudden lesion will produce loss of power in the muscles of the lower abdomen to be followed by gradual atrophy and electrical reactions of degeneration. If the lesion is complete, all motion and sensation is lost below. If incomplete, because of the implication of the crossed pyramidal tracts, there will be weakness in both lower limbs, with spastic condition, increased reflexes and Babinski phenomenon. If the lesion is unilateral as in the Brown-Séquard syndrome these symptoms, of course, will be only on the side of the lesion. Muscle reflexes will be also interfered with in the distribution of the cells of the anterior horn.

Sensory Symptoms.—The posterior roots which enter the ninth and tenth thoracic segments are in relation with the root areas which run through the line of the umbilicus, and therefore there will be disturbance

of all forms of sensation in the abdomen to a line corresponding with that of the umbilicus. If the lesion is complete all sensation is lost below this area. If the lesion is of the Brown-Séquard type there will be the root disturbance mentioned, with a disturbance of sensation for touch and muscle sense in the abdomen and lower limb on the same side with alteration of pain and temperature sensations in the lower abdomen and lower limb on the other side.

Lesions of the Lumbar Cord.—The lumbar cord is so small, containing only five segments, that a lesion in any portion is likely to take in all parts of the lumbar cord.

Motor Symptoms.—The cells of the anterior horn supply, roughly speaking, the muscles of the lower limb. Therefore a sudden lesion would produce loss of power in the muscles of the legs followed by gradual atrophy and electrical reaction of degeneration. If the lesion is complete all motion and sensation is lost in the lower limbs. If incomplete, because of the implication of the crossed pyramidal, there will be weakness in the lower limbs, with spastic condition, increased reflexes and Babinski phenomenon. If the lesion is unilateral, as in the Brown-Séquard syndrome, these symptoms, of course, will be only on the side of the lesion. There will be disturbances in the knee-jerks on one or both sides, because the centers for these are in the second to the fifth lumbar segments inclusive. The cremasteric reflexes will also be interfered with because their center is in the first lumbar segment. There will also be disturbances in the bladder and rectal functions.

Sensory Symptoms.—The posterior roots entering the lumbar cord supply, roughly speaking, sensation for the lower limbs. It is best to consult a diagram for this. If the lesion is incomplete all sensation is lost below this area. If the lesion is of the Brown-Séquard type there will be the root disturbance mentioned, with a disturbance of sensation for touch and muscle sense in the limb on the side of the lesion, with pain and temperature disturbances in the limb of the opposite side.

Lesions of the Sacral Roots.—These are even smaller than the lumbar segments and a lesion in any portion is likely to involve all parts of this cord.

Motor Symptoms.—The cells of the anterior horn and the roots coming from these segments supply the muscles of the perineum, bladder, genitals and pelvis. Therefore a sudden lesion will produce loss of power in these parts, to be followed by gradual atrophy and electrical reactions of degeneration. Unilateral lesions are rarely present. The Achilles jerk is interfered with either on one or both sides, because the center for the Achilles tendon reflex is in the first and second sacral segments. Muscle reflexes will also be interfered with in the distribution of the cells of the involved anterior horns.

Sensory Symptoms.—The posterior roots which enter the sacral segments supply the portions of the perineum, rectum, anus and genitals. It is best to consult a diagram. There will always be a disturbance of rectal and bladder control and of sexual functions.

TUMOR OF THE SPINAL CORD.

This term has been used rather loosely to designate any form of tumor growing within the spinal canal. It should be limited to those tumors which invade the cord itself. Spinal tumors may be classified as follows:

1. Extradural.
2. Intradural.
3. Extramedullary.
4. Intramedullary.

FIG. 323 FIG. 324 FIG 325

FIGS. 323, 324 and 325.—Tumor of the spinal cord.

Starr states that of 302 tumors of the cord 125 were intramedullary or within the cord itself. Flatau found in a series collected by him 57 intramedullary tumors in 213 cass. Elsberg found in 44 cases operated by him 10 extradural, 22 extramedullary and 12 intramedullary tumors. In this series the growths were fibroma, sarcoma, glioma, psammoma, lipoma, endothelioma and tuberculous tumors; neuroma, cholesteatoma, myxoma, teratoma, adenoma and cysticercus have also been found.

It is not always possible to distinguish, before operation, between extradural, intradural and extra- or intramedullary growths. Extradural growths are comparatively rare, and are usually fibromata or sarcomata, or a combination of the two. The malignancy of extradural sarcoma is rather low, as these tumors are more or less circumscribed and do not show a marked tendency to recur after removal. The

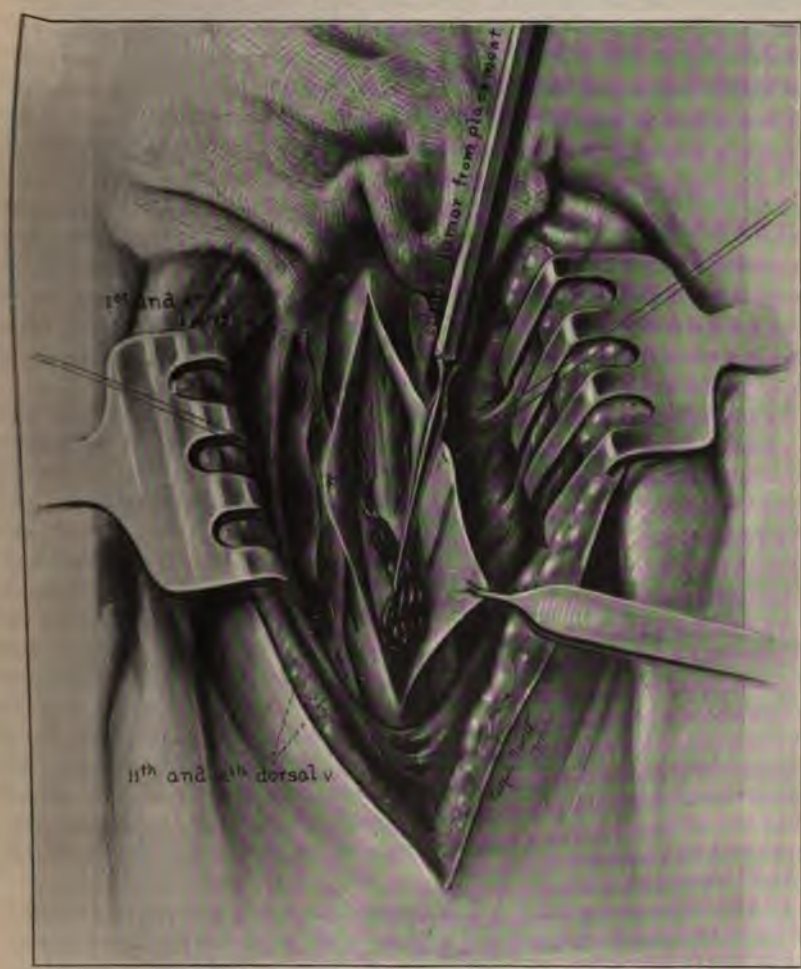

FIG. 326.—Angioma of the spinal cord. (Adson.)

symptoms produced by extradural growths depends upon their location and whether or not posterior nerve roots are involved in the growth of the tumor. If the tumor grows near and presses upon a nerve root there will be severe root pain. Extradural sarcoma takes its origin from periosteum, as a rule, although it may arise from the dura itself and causes a certain amount of bone absorption, while fibromata do

not cause bone absorption. The motor symptoms, as well as sensory symptoms in extradural growths, are not constant and will vary in degree from time to time. One set of symptoms may be rather distinct as the motor symptoms, while the sensory symptoms may be vague.

The old rule was that it was comparatively simple to distinguish between extradural and intramedullary growths, as extramedullary tumors were always painful from the beginning and intramedullary were usually not so. Elsberg states that this rule no longer holds true, as in one-third of his patients presenting extramedullary growths there was no history of early root pains. As a rule it is difficult to distinguish before operation between extramedullary and intramedullary growths, although it may be done. The progress in extramedullary growths is slow at first and characterized by no special train of symptoms. Increasing weakness of the lower extremities, Brown-Séquard syndrome and dissociation of sensations on the side of the greatest sensory loss are sometimes present. In intramedullary growths there is usually a painless beginning, although this is not an inflexible rule, as early root symptoms have been noticed. Dissociations of sensations occuring over the entire area of sensory disturbances, according to Elsberg, always means disease within the substance of the cord.

Reflexes of Defence.—Reflexes of defence, first observed by Prochaska as long ago as 1784 and recently popularized by Babinski, are of considerable value in the localization of cord lesions. Babinski attributes much importance to these so-called reflexes of defence in determining the level of spinal-cord lesions. These reflexes consist in involuntary contraction of the extremities upon irritation, such as pinching the sole of the foot. The action is one of flexion of the foot on leg, leg on thigh, and thigh on the abdomen. Spiller[1] states that a distinct advance in the diagnosis of spinal lesions has been afforded in Babinski's reflexes of defence, by which is meant a forcible withdrawal of the lower limbs from irritation of these limbs. By these reflexes some idea of the destruction within the cord, and from the extent upward in which cutaneous irritation produces them, some idea of the lower level of the lesion may be obtained. Babinski remarked that great contracture of the lower limbs in flexion occurs only when anesthesia of the limbs has not developed or is slight, and the pyramidal tracts are not degenerated or are only slightly degenerated.

Auer[2] has done wisely in calling the attention of American physicians to this important symptom-complex, and in reporting two cases, although neither was with necropsy. As he gives Babinski's views the chief characteristic of this form of spastic paraplegia is contracture of the limbs in flexion, the tendon reflexes being usually not exaggerated and often diminished, while the cutaneous reflexes are so markedly increased that irritation of the skin on the paralyzed side causes

[1] Prog. Med., September, 1913, p. 271.
[2] Jour. Am. Med. Assn., January 25, 1913, p. 269.

defensive movements of rapid withdrawal in flexion of the limb. It differs from the usual type of spastic paraplegia from degeneration of the pyramidal tracts in the contracture of the lower limbs in extension and exaggeration of the tendon reflexes. Babinski's form is often caused by a gradually progressing compression myelitis. The complex may be found in Friedreich's ataxia and in multiple sclerosis, in which the axis-cylinders in the pyramidal tracts largely escape, although the myalin sheaths may be degenerated. It may occur in Pott's disease from compression of the cord. It is highly important, as Auer remarks, to be able to distinguish clinically between a paraplegia due to degenerative changes and pressure not producing marked secondary degenerative changes. In the former case treatment is of little value; in the latter the prompt removal of the compression by surgical or other measures may be followed by great improvement. There is much need of attention by neurologists to this important complex and to a more accurate determination of its value.

More recent investigations make the reflexes of defence of doubtful value in deciding clinically between paralysis with and paralysis without degeneration of the pyramidal tracts. Dejerine and Long[1] reported at a meeting of the Neurological Society of Paris a case in which complete destruction of the cord in the cervical region had existed for almost eleven months and a necropsy had been obtained. The condition was one of flaccid paraplegia with loss of all superficial and deep sensation of the lower limbs and trunk. The patellar and Achilles reflexes were lost, but the abdominal and cremasteric reflexes were normal. This observation would seem to prove that the cutaneous reflexes are of spinal origin, contrary to the opinion of Bruns, Crocq and van Gehuchten. The reflexes of defence produced by irritation of the skin or deeper parts were remarkably intense in both lower limbs, and yet the pyramidal tracts were degenerated. The plantar reflex was in flexion and not extension, as might be expected in such a case. This observation seems to prove that the extension of the toes is not conditioned solely by degeneration of the pyramidal tracts but that the superior centers in some persons may have an influence on this extension reflex.

Rose reported a similar case, with the reflexes of defence, in the discussion following the report of this case, and Babinski also referred to a similar case in which these reflexes were preserved, but did not appear to be of greater intensity than in normal persons.

The chief value of the reflexes of defence seems now to be in the determination of the lower level of a lesion in the spinal cord. Babinski, Lacene and Jarkowski[2] report a case of extradural tumor in which the lower limits were accurately determined by reflexes of defence.

Among other inportant localizable signs is a symptom-complex of

[1] Revue Neurologique, December 30, 1912, p. 760.
[2] Ibid., June 30, 1914, p. 801.

Oppenheim which is a trophic paresis of one side of the abdomen with disturbances of sensation and loss of the abdominal reflexes on the same side. The abdominal reflex lies in the eighth to twelfth thoracic roots inclusive. A case in which this symptom was of value in localizing the tumor was one reported by Soderbergh.[1] In this patient there was an almost permanent hypertonia of the abdominal muscles. The entire abdomen being as hard as a board, all reflexes and voluntary movement of the abdomen were missing. Pain in the left hypochondria had been an early symptom, but objective disturbances of sensation were not present. The seventh thoracic roots at operation were found much stretched by a tumor and the spinal cord was pressed upon. The hypertonia of the abdomen was caused by implication of the cord at the level of the seventh root. This symptom-complex is indicative of a lesion at the part of the cord supplying only the upper abdomen.

The cerebrospinal fluid in tumor of the cord is sometimes characteristic and of diagnostic value. The fluid obtained by lumbar puncture below the level of the tumor may be intensely yellow, a condition which has been described as xanthochromia. Raven[2] found this condition of the spinal fluid present in 8 of 24 cases of extradural compression and in 11 of 16 cases of intradural compression. Increase in the albumin contents of these cerebrospinal fluids is also suggestive of pressure. Klineberger[3] has observed xanthochromia in 4 cases of extramedullary tumor of the cord. The fluid was clear and contained no blood. Fibrin coagulum formed very quickly.

J. B. Ayer and Viets[4] have carefully reviewed the literature on spinal fluid findings characteristic of cord compression and add their own findings in 12 cases confirmed by operation and autopsy. Froin[5] was the first to call attention to abnormal findings in the spinal fluid the result of pressure on the spinal cord. His cases showed three abnormal characteristics, a yellow color or xanthocromia, spontaneous coagulation and an increase in the cell count. Mix,[6] in 1916, reviewing the literature, found 33 cases reported and added 1 of his own; Demole[7] and Bromer[8] have each reported cases, making 36 in all. These 36 cases fall into three groups: (1) Meningitis, (2) pachymeningomyelitis of the conus terminalis and (3) cord tumors. Since the report of these cases several important papers have appeared, notably Nonnes. The latter[9] reported the spinal fluid findings in 16 cases proved by operation or autopsy. He states that (1) the examination of spinal fluids seems to give us a compression syndrome by the increase in globulin, with slight or no lymphocytosis and either with or without a yellow color; (2) the increase of albumin in the spinal

[1] Deutsch. Ztschr. f. Nervenh., xliv, 202.
[2] Deutsche Zeitschrift f. Nervenheilkunde, Nos. 1 and 2, xlix, 36.
[3] Monatsschrift f. Psychiatrie und Neurologie, No. 4, xxviii, 346.
[4] Jour. Am. Med. Assn., December 9, 1916, No. 24, vol. lxvii.
[5] Gaz. d. hôp., 1903, lxxvi, 1005.
[6] Clinics of John B. Murphy, 1915, iv, 317.
[7] Rev. Neurol., 1915, xxviii, 648.
[8] Am. Jour. Med. Sc., 1916, cli, 378.
[9] Deutsch. Ztschr. f. Nervenh., 1913, xlvii, 436.

fluids in cases of tumor is probably due to stasis distal to the point of compression and not to inflammation. In regard to the cause of these findings various explanations have been offered. Some (Cestau and Ravaut) think the deep yellow color is due to the dissolution of the red blood corpuscle and consequent freeing of hemoglobin and that the increase in albumin is due to the serofibrinous exudate of the inflammation. Tannois, Froin and Ledoux think the yellow color is due to local hemolysis or exudation of blood plasma. The original syndrome of Froin consisted of xanthochromia and spontaneous coagulation, with increase in the cell count. Later, Nonne and Raven have shown that a low cell count, marked increase in protein content, with or without xanthochromia, are quite characteristic of cord compression. Ayer and Viets believe as the result of the findings in twelve cases of cord compression which came under their own observation, that the principal characteristic of compression is marked increase of proteins without corresponding cellular increase obtained under normal pressure. They state that xanthochromia and massive coagulation added to the increase in proteins makes the diagnosis more certain and that pressure on the lower cord is more liable to produce the symptom-complex. All agree the above findings in the cord are not necessary evidence of compression but that its presence is confirmatory and a definite aid in diagnosis.

Pearce Bailey[1] discusses unusual symptoms of spinal tumor, such as choked disk associated with tumor in the upper part of the spinal cord. Taylor and Collier found no case in which choked disks appeared when the lesion was below the third thoracic segment. Tumor of the spinal cord sometimes occurs without pain. Cases are reported by Pearce Bailey and by Schultze and Stersberg. Tumors of the spinal cord at times grow to considerable size, as is evidenced by the case reported by Robertson and Ingham.[2] This tumor apparently had its origin in the cord substance superficially and covered five and one-half inches in length and about one inch in width at its widest portion. Microscopic sections showed it to be cholesteatoma. The cord was exposed at the level of the twelfth spinal segment and the spines and laminæ of the tenth thoracic to the third lumbar vertebra inclusive were removed. Removal of the tumor was followed by improvement of the symptoms.

Diagnosis.—The diagnosis, then, of spinal cord tumor will rest upon (*a*) the history and (*b*) the physical findings. In the history the essential features will be pain and weakness of either upper or lower extremities, or both, depending upon the location of the tumor and perhaps of the bladder and rectum as well. The essential findings in the physical examination will be: Motor weakness, disturbances of sensation, reflexes of defence and the symptom-complex of Froin in the cerebrospinal fluid. In order to determine the exact level of the tumor one must know the symptoms characteristic of lesions at various levels

[1] Med. Record., March 12, 1910.
[2] Pennsylvania Med. Jour., March, 1916.

of the cord already set forth (p. 826) as well as follow the table of muscle supply by spinal nerves (p. 853).

Prognosis.—The prognosis of spinal cord tumor depends largely upon the variety of the growth. If the tumor be extramedullary its removal can usually be thoroughly accomplished and the results are highly satisfactory. If the patient has presented him or herself for operation early the recovery from symptoms is rapid. We have seen in at least two cases of extradural fibroma rapid disappearance of all symptoms, so that in six weeks in one case and two months in the other there was no trace of symptoms remaining. In the case of intramedullary tumors the prospect is, of course, not nearly so good. The majority of these tumors are infiltrative in character, usually glio sarcomata, and it is absolutely impossible to remove them entirely. Improvement following the removal of intramedullary tumors has been reported by Elsberg, Schultze, von Eiselsberg and Ropke. Starr gives the average duration of symptoms as sixteen months and Harte two and one-half years. Horsley and Schlesinger have shown that extradural tumors have a duration of fourteen months and intramedullary twenty-six months. Burns has found that intradural fibropsammoma may last from four to fourteen years. Merzbacher and Castex report a case of intradural fibroma which grew eighteen years.

Treatment.—Operation is the treatment of choice in dealing with tumor of the spinal cord. We believe that exploratory laminectomy should be done more frequently for symptoms suggestive of cord tumor, for even though a large number will prove to be inoperable, improvement in symptoms will follow decompression of the cord.

Results of Operative Treatment.—The success of operative treatment will depend largely upon how early the case comes to operation. Obviously, continued pressure on the cord, will cause degenerative changes that will not disappear even after the successful removal of a tumor. Thus we cannot hope that paraplegias which have existed for years will disappear after operation, and yet, on the other hand, there is no field of surgery more satisfactory when the happy combination of operable tumor, removed early, exists. In such cases symptoms will quickly clear up and in from four to six weeks all trace of the condition disappear. We have seen this occur and others (Elsberg, etc.) report such instances. As Elsberg states, "The operative mortality varies largely among individual operators." Horsley operated upon 20 successive cases without a death; in 26 operations by Fedor Krause there was a mortality of 37 per cent. In 92 cases collected by Harte there was an operative mortality of 47 per cent. Elsberg has operated upon 22 extramedullary tumors without a death. We think, as did McCosh, that 10 per cent. should fairly represent the operative mortality, which is fairly well in keeping with that of other major surgical procedures of similar gravity.

According to Elsberg the most frequent tumor in the conus and cauda equina is the giant endothelioma or endothelial sarcoma. Five

cases of this type of tumor were described by Collins and Elsberg.[1] Spiller[2] reports 9 cases of tumor of the cauda equina. There were 7 autopsies in this series and 3 cases came to operation. It is rarely possible to remove tumors of the cauda equina, since they are infiltrative and of sarcomatous origin and involve nerve roots.

Kleineberger reports a case of improvement following an operation for tumor of the cauda equina. We have had no experience in operating upon tumors of the cauda equina, and are inclined to agree with Spiller that operative removal must be exceedingly difficult because of the involvement of nerve roots. In general, tumors of the cauda equina cause more pain than tumors of the cord proper and are inoperable. Schlesinger[3] has observed what he describes as a stretching symptom in disease of the cauda equina. He has observed 7 cases within the past eight years of tumor of the cauda equina in which there was violent pain while sitting, the pain being particularly severe in the anal region and genitalia or rectum. Schlesinger regards this symptom as somewhat analogous to Kernig's sign and believes that both are due to stretching of roots fixed by inflammatory exudate. Oppenheim[4] reports 2 cases of tumor of the cauda equina in which the symptoms resemble sciatica. Lumbar puncture gave xanthochromia and a great increase in albumin. Slight hypalgesia about the anus was the only other sign suggesting tumor.

CIRCUMSCRIBED SEROUS SPINAL MENINGITIS.

This condition was first described by Oppenheim and later by Horsley, Krause and Borchard.

Pathology.—It is often secondary to inflammatory processes in the pia arachnoid. It may be a complication of syphilis, meningomyelitis, or pachymeningitis (Elsberg). There are adhesions formed between the inner layer of the dura and arachnoid or between the arachnoid and pia resulting in walled-off collections of fluid, compressing nerve roots and cord. Gerstmann[5] states that the circumscribed collection of fluid has been known to follow operative trauma or to appear above or below the level of a tumor.

Symptoms.—These are much the same as produced by extramedullary tumor. There is a gradual onset with root symptoms first appearing, to be followed later by level symptoms.

Treatment.—The treatment is laminectomy. It may be necessary to stitch the dura open so as to provide for permanent drainage into the muscles.

[1] Am. Jour. Med. Sc., March, 1914.
[2] Ibid., March, 1908, p. 365.
[3] Neurol. Centralbl., July, 1915, p. 450.
[4] Monatschr. f. Psychiat. and Neurol., December, 1914, p. 391.
[5] Ztschr. f. d. ges. Neurol. and Psychiat., No. 2, xxlx, 97.

NEURITIS OF THE CAUDA EQUINA.

This condition was described by Elsberg and Kennedy[1] and also by Oppenheim. It is a non-syphilitic inflammatory condition of the nerves of the cauda, resulting in ascending degeneration in the spinal cord.

Symptoms.—The disease usually began, as in the case reported, with sharp, shooting pains in the backs of the thighs and calves. Atrophy of the anterior tibial muscles with loss of power of dorsiflexion at the ankle is a permanent feature. Sacral roots were more severely affected than the lumbar. There was complete loss of bladder and rectal control. At operation a large number of caudal roots were swollen,

FIG. 327.—Abnormal varicose vein on the posterior surface of the cord. (Elsberg's Surgery of the Spinal Cord, copyright by W. B. Saunders Company.)

congested and of a bluish-red color; the changes were due to intense hyperemia and there were no adhesions. The dura was smooth and there was no evidence of inflammation. In its symptomatology this condition closely resembles tumor of the cauda equina.

Treatment.—The treatment consists of laminectomy, following which Elsberg has seen improvement in several cases. The congested nerves were wiped over with sponges dipped in 1 to 500 bichloride of mercury

[1]Am. Jour. Med. Sc., May, 1914.

PLATE IX

Neuritis of the Cauda Equina.

(From Elsberg, Diseases of the Spinal Cord.)

solution. Elsberg states that it is still an open question whether caudal neuritis should be subjected to operation or not, since he has seen one case of spontaneous recovery.

FIG. 328.—Enlarged branch of a posterior spinal vein which accompanied the eighth dorsal spinal root on the left side. (Elsberg's Surgery of the Spinal Cord, copyright by W. B. Saunders Company.)

VARICOSE VEINS OF THE SPINAL CORD.

Elsberg[1] reports 6 cases occurring in the course of 130 laminectomies. These cases were characterized by one or several enlarged veins on the posterior surface of the cord. In all but one of the patients the large vein ran a straight course and in several instances the enlarged vein accompanied one of the spinal roots to the dural opening. All the patients had the signs and symptoms of a lesion at a definite level and the greatest or only enlargement of the vein was found at the part of the cord corresponding to the symptoms. Two of his patients suffered

[1] Am. Jour. Med. Sc., May, 1916, p. 642.

from severe root pains and the veins were found to accompany the affected spinal roots. Up to the year 1912 4 cases had been reported in the medical literature in which compression of the spinal cord by enlarged spinal veins had occurred. Gaupp[1] described a case of what he termed "hemorrhoids of the spinal pia mater," in which the lumbar cord was compressed by the dilated and tortuous vessels. Jumentie and Valensi[2] describe the postmortem appearances of the spinal cord in a patient with complete paraplegia. On the posterior surface of the cord, between the lower cervical and middle dorsal segments, there were numerous dilated veins. Some of these veins accompanied the nerve roots to the dural openings. Finally, Lindemann[3] describes a case of varices of the vessels of the spinal pia mater and the cord as the cause of a total transverse lesion. The patient had the signs and symptoms of a slowly progressive transverse lesion of the cord of two years' duration and succumbed to decubitus and sepsis. At the postmortem examination the veins on the posterior surface of the cord, beginning about 7 cm. below the cervical enlargement, were much dilated and very tortuous, so that they caused a marked flattening of the cord.

The case described by Krause[4] is the only one in which the abnormality of the spinal vessels was found on the operating table. Krause's patient presented the symptoms of an intradural growth of seven years' duration which had caused a complete paraplegia. At the operation he found a mass of dilated veins, some of which entered the cord at the level of the ninth to the twelfth dorsal vertebræ. The operator was able to ligate a number of the vessels, but the patient did not improve and death occurred three months later. He concludes there was some connection between the enlargement of the vein and the cord symptoms. Whether the venous enlargment was the primary condition and the cord disease was secondary or whether the reverse was the case, or whether both played a part in any of the patients, he finds it impossible to say with certainty. In two the symptoms and signs were so similar to those of a spinal tumor that a diagnosis of spinal tumor had been made. The discovery of the enlarged or varicose vein was in each instance an operative finding. That the abnormality was not temporary, perhaps resulting from exposure of the cord and the change in pressure conditions, was proved by the fact that the spinal vein of the other side always appeared normal in size and position.

The results obtained by excising these enlarged veins are interesting. Of the 6 patients reported by Elsberg 2 had spastic paraplegia, with sensory level symptoms of long standing, and their condition was unchanged after the operation. A patient with tuberculoma of the

[1] Beitr. z. path. Anat. u. z. Allg. Path., 1888.
[2] Rev. neurol., 1911, xlx, 81.
[3] Ztschr. f. d. ges. Neurol. u. Psychiat., 1912, xii, 522.
[4] Chirurgie des Gehirns und Rückenmarks, 1911, p. 775.

cord improved very much, but the improvement was from removal of the growth. A patient who had suffered from severe root pains confined to the distribution of the left eighth thoracic root, and in whom a much enlarged vein ran with the root, was entirely relieved by the laminectomy and excision of the large vein. Two patients were supposed to have spinal tumor, but nothing excepting the localized venous enlargement was found at the operation. Both patients had well-marked sensory and motor signs, and marked improvement followed the surgical intervention. One of the patients recovered entirely; it may be, Elsberg states, that this remarkable result was caused by the decompressive effect of the laminectomy.

PREPARATION OF THE PATIENT FOR OPERATION.

Because of paralysis of the bladder and rectum, and often decubitus, patients with a spinal cord lesion are not usually in a favorable condition for operation. Much can be done to improve the patient's condition, and, therefore, the preparation is important. If catheterization be necessary it should be done at regular intervals and, of course, cleanly done. Should cystitis already be present the bladder may be irrigated daily with silver nitrate solution (1 to 8000), followed by a saturated solution of boric acid. Hexamethylenamine may be given in 10-grain doses, three times daily, for four or five days, for its antiseptic effect on the urine. Recent work has shown that this drug is not eliminated as formalin in the cerebrospinal fluid, and, therefore, there is no object in giving it with the idea of lessening the chance of infection from operation. The bowels may be moved by enemata. The skin of the back especially needs attention. Careful nursing may prevent decubitus and heal those already present. These bed-sores should be cleansed daily with some antiseptic solution, such as bichloride of mercury, weak potassium permanganate (1 to 10,000) or weak carbolic solution, and dressed with a suitable ointment. We have found ordinary zinc oxide ointment satisfactory. A paste made of equal parts of alum and egg white is at times useful, especially at the stage when the skin is just about to break down. The patient's strength should be built up by nourishing food and tonics. The immediate preparation for operation consists in preparing the skin of the back in the region of the proposed laminectomy, by the usual technic; we prefer washing with tincture of green soap, shaving if necessary, applying alcohol and ether and thoroughly drying, covering the area with dry sterile gauze. This is done on the evening preceding operation. On the morning of the operation the skin is painted with one-half strength tincture of iodin, allowed to dry thoroughly. Finally, on the operating table, another coat of one-half strength tincture of iodin is applied. The patient is given on the afternoon preceding the operation a purgative, preferably, 1½ ounces of castor oil

and an enema if necessary on the following morning. Nothing but water is allowed by mouth after midnight if the operation is to be in the morning. Three-quarters of an hour previous to operation a hypodermic of morphin sulph., gr. $\frac{1}{6}$, atropin gr. $\frac{1}{150}$ is given. The choice of anesthesia and the method of its administration is of the greatest importance. For cervical laminectomy we greatly prefer intratracheal or intrapharyngeal ether, and have found Elsberg's apparatus very satisfactory. As the patient must be prone on the table it is well to have the head extend over the edge of the table, supported by some form of special head support. We have found, both for cervical laminectomy and suboccipital craniotomy, the head rest of Sachs to be very satisfactory. It is necessary to have the shoulders supported away from the table, as otherwise respiration would be embarrassed.

For laminectomy in the dorsal or lumber region the semiprone position is the one of choice, the patient being turned toward either side and supported by sandbag or pillows. Nitrous oxide-oxygen and ether is given, the latter by the open drop method, after anesthesia has been well established. The postoperative treatment is largely symptomatic. The patient is placed on an air mattress; if shock is present he is treated in the usual way; hypodermoclysis of normal salt solution, morphin, etc.

TECHNIC OF LAMINECTOMY.

We have found the simplest method of exposing the cord to be the one of choice. The osteoplastic methods formerly in vogue, such as Urban's, Abbe's or Bickman's, are more complicated than simple laminectomy, and have nothing to recommend them. In performing the operation of laminectomy the first step is an incision in the median line of the back, directly over the spinal process, four or five inches in length, taking in at least three spines. This incision is carried through the skin and superficial fascia down to the muscles; the latter are then pushed away with Kocher's dissector from the spines, using the scissors when necessary to facilitate the separation. It is well to work first on one side and then on the other, packing the side which is not being worked upon with cotton wrung out of hot salt solution. In this manner hemorrhage may be checked and the entire operation done, with the loss of a surprisingly small amount of blood. After the muscles have been well separated from the spines and laminæ the intraspinous ligament is divided with the knife between each of the spinous processes. With a large, curved pair of bone-cutting forceps the spines are removed down to the base exposing the laminæ. In the cervical region, as well as the upper dorsal, the spinal canal will have been opened after removing the spinous processes at their bases, but in the lower dorsal and lumbar region further removal of bone will be required. It has been our custom to use for this purpose the Hudson bone drill, by means of which rapid and safe entrance can be made into the canal. Laminæ are then removed, as far outward as the articular

FIG. 329.—Laminectomy. I, the skin incision. (Elsberg's Diseases of the Spinal Cord, copyright by W. B. Saunders Company.)

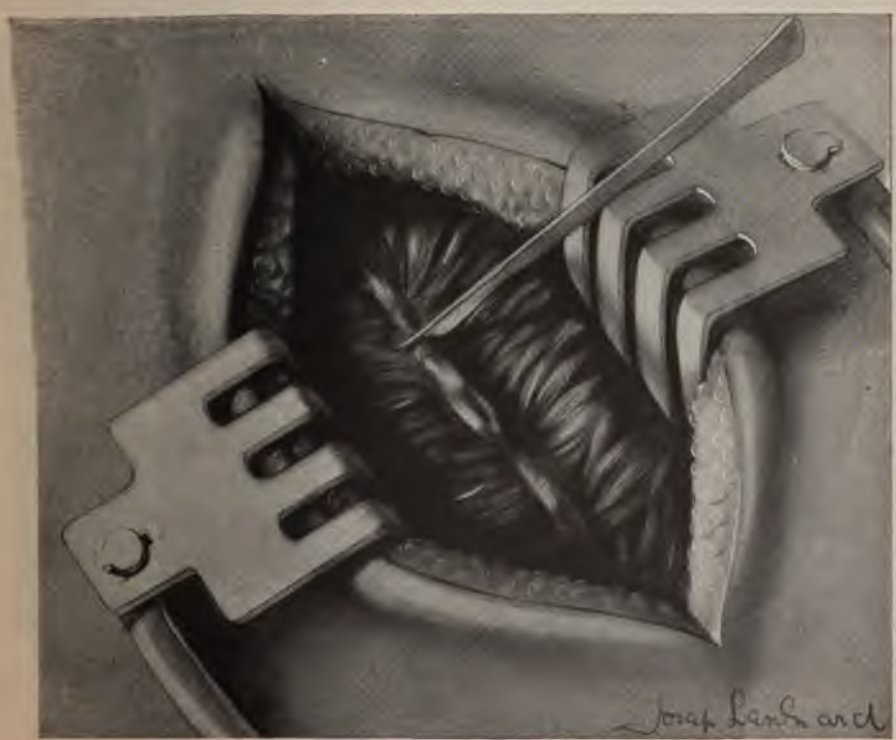

FIG. 330.—Laminectomy. II, the division of the interspinous ligaments. (Elsberg's Diseases of the Spinal Cord, copyright by W. B. Saunders Company.)

FIG. 331.—Laminectomy. III, the removal of the spinous processes. (Elsberg's Diseases of the Spinal Cord, copyright by W. B. Saunders Company.)

FIG. 332.—Laminectomy. IV, the dura exposed. (Elsberg's Diseases of the Spinal Cord, copyright by W. B. Saunders Company.)

FIG. 333.—Laminectomy.V, the incision of the dura.(Elsberg's Diseases of the Spinal Cord, copyright by W. B. Saunders Company.)

FIG. 334.—Laminectomy.VI, the tumor exposed.(Elsberg's Diseases of the Spinal Cord, copyright by W. B. Saunders Company.

FIG. 335.—The method to be followed in exposing the anterior surface of the cord. (Elsberg's Diseases of the Spinal Cord, copyright by W. B. Saunders Company.)

FIG. 336.—Laminectomy. VII, the suture of the dura. (Elsberg's Diseases of the Spinal Cord, copyright by W. B. Saunders Company.)

process, with small rongeur forceps, which will complete the bone work and expose the dura. We usually prefer to work from below upward. Before opening the dura it is necessary to have a dry field and good retraction at each angle of the wound. Self-retaining retractors answer well for this purpose. Careful toilet of the wound is then made; rubber gloves are rinsed well, or if they should be torn in performing the bone work they must be changed. The dura is then opened, first passing two traction sutures of silk to either side of the median line

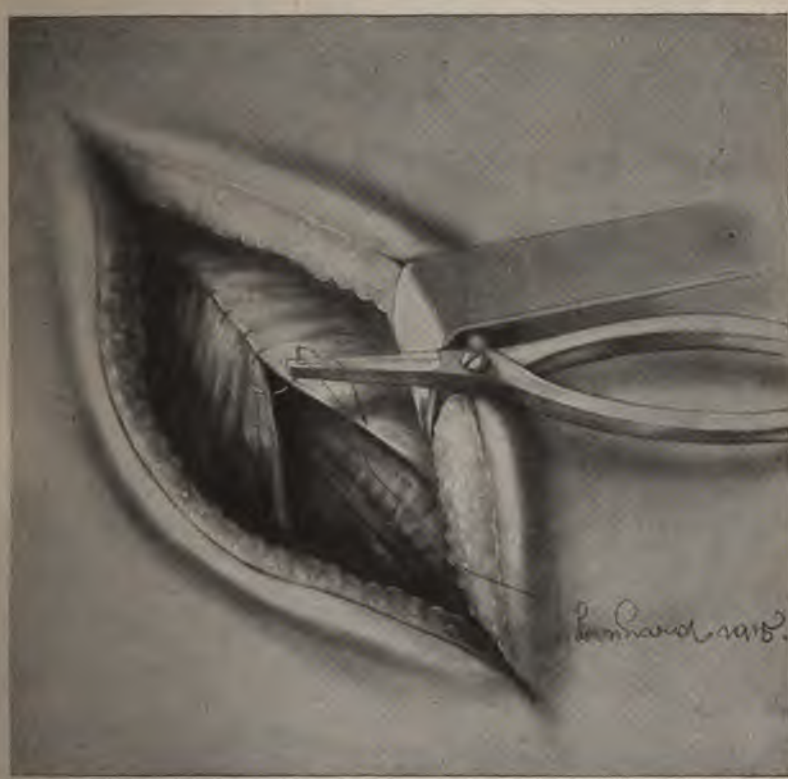

FIG. 337.—Laminectomy. VIII, the suture of the muscles and fascia. (Elsberg's Diseases of the Spinal Cord, copyright by W. B. Saunders Company.)

and making a small opening with the knife between them. This opening is enlarged in both directions, with blunt-end scissors, until the cord is exposed sufficiently well to allow for any further procedure that may be necessary. The escape of the cerebrospinal fluid upon opening the dura has been said to be productive of alarming symptoms, but we believe that this bugbear may be disregarded, as we have never seen any ill-effect from the escape of the fluid, the flow soon ceasing after the first gush.

Further operative procedure will depend upon diseased conditions

for which laminectomy has been done. If there is an extramedullary tumor it may be removed without damaging in any way the cord tissue by careful and painstakingly separating the tumor from the cord. If there is an intramedullary tumor one would never remove or attempt to remove it by dissection, as the cord tissue would be damaged to an unwarranted extent. Elsberg's method of removal of intradural tumors is the best—in fact, it is the only way that these tumors can be safely removed. He calls this method "removal of intramedullary growth by the method of extrusion."

FIG. 338.—Laminectomy. IX, the suture of the skin. (Elsberg's Diseases of the Spinal Cord, copyright by W. B. Saunders Company.)

A short incision, about 1 cm. in length in the posterior median column, is made a few millimeters outside of the posterior median fissure at the spot where the growth seems to be nearest the surfaces of the cord. The incision made in the manner described should be deep enough to divide the pia and the substance of the cord down to the

tumor. The tumor will then be extruded of itself by reason of intramedullary pressure. No matter how much the tumor protrudes after incision of the cord at the first stage of the operation the surgeon should

FIG. 339.—Division of the antero-lateral tracts. To illustrate the exposure of the antero-lateral tract and the direction in which the knife is introduced. × 2. (Elsberg's Diseases of the Spinal Cord, copyright by W. B. Saunders Company.)

not attempt its removal until at least one week has elapsed. The dura being left wide open, the muscles, fascia and skin, are carefully closed. At the second stage, after about a week, the wound is reopened and the tumor, which may entirely extrude from its bed within the

cord, may be found entirely outside of the cord and can then be removed by dividing the few remaining adhesions. We have used this method of extrusion in several cases of intramedullary tumors and found it to work very well. The closure of the wound will depend upon whether or not all of the work can be accomplished at one sitting. We have formerly been inclined to favor a two stage operation. Each case must be decided on its own merits, the condition of the patient and the amount of work to be done being the controlling factors. It is our custom to have blood-pressure readings taken frequently during the course of the operation, and if there should be a sudden fall, especially, should the systolic pressure drop below 100 m.m., it is wise to wait for another stage to complete the work. With increasing experience we find that usually the entire procedure can be accomplished at one stage without marked shock, much less than usually accompanies operations upon the brain in our experience. As has been said, when one is dealing with an intramedullary tumor the operation must be done in two stages. In closing the wound the dura should be carefully sutured with find black silk, the muscles and fascia sutured in layers with chromic catgut and the skin coaptated by silkworm-gut sutures. As a general rule it is not only unnecessary but even unwise to drain if hemostasis has been carefully and thoroughly accomplished. As has been said in dealing with collections of fluid it may be wise at times to allow the dura to remain open. If the dura and muscles have been well closed there should be no lasting drainage of cerebrospinal fluid, although we have seen it follow laminectomy for a few days in spite of a careful closure.

The after-care of patients upon whom laminectomy has been done is important. They should be placed on an air mattress, and if there is any shock, should be given normal salt solution by hypodermoclysis. Careful attention must be paid to the bladder and rectum and skin. If there is cystitis present bladder irrigations of boric acid (salt solution) or silver nitrate solution (1 to 8000) may be used. Catheterization must, of course, be carefully done. The bowels may be moved by enemata. We have not found it necessary to use any form of support, as a splint or plaster cast. The weight of the vertebral column falls almost entirely on the bodies of the vertebra, so that removing the spines and laminæ of even six vertebræ interferes but little with the strength of the column. When laminectomy has been done in the cervical region, however, it will be well to place the head between sandbags. Three or four weeks should be spent in bed.

RHIZOTOMY.

Division of the posterior nerve roots may be done for (*a*) pain or (*b*) spasticity.

Rhizotomy, proposed for the relief of intractable neuralgia by Dana, was first performed by Bennett in 1886 and by Abbe in 1888. Though commonly referred to as division of the posterior roots in reality the nerves are resected. Though founded on sound reasoning this pro-

cedure has not lived up to expectations, and, yet, we feel has a definite place in spinal cord therapy.

Indications.—(*a*) *For the Relief of Pain.* It is impossible to tell what patient will be relieved by resection of the posterior roots. We feel that, as a last resort, the operation is entirely justifiable to relieve pain that remains unrelieved by local operations and for which drugs must constantly be used. Such conditions as painful stumps, lightning pains of tabes, gastric crises, inoperable tumor of the cord or vertebræ may be relieved, at least for a time, by resection of the posterior roots.

(*b*) *For Spasticity.* O. Foerster,[1] of Breslau, recommended the resection of posterior roots for spasticity and reported a series of cases collected from the literature. The theoretical basis for this procedure is that by resection of the posterior roots the reflex arc is broken, since muscle tone is partly controlled by stimuli from the periphery through the posterior spinal roots to the motor cells of the gray matter of the cord. Inhibition comes through the pyramidal tracts from the higher centers. Clinical observations have been made that a decrease in spasticity of mutiple sclerosis ensues consequent upon the development of disease of the posterior columns and roots (tabes). Foerster, reasoning from this clinical observation, concludes that spasticity should be diminished if the stimuli from the periphery were excluded by division of the appropriate sensory spinal roots.

Rhizotomy has been done mainly for the spasticity of congenital spastic diplegia (Little's disease), although other spastic conditions have been treated in this manner. Great care should be used in selecting cases of Little's disease for rhizotomy. It should not be done in patients who can be materially benefited by other and less drastic means, such as massage, gymnastics, tenotomies and other muscle operations or by Stoeffel's operation (intramuscular division of nerves). It also should not be done in patients whose mentality is not sufficiently good to allow for coöperation in a prolonged post-operative treatment. In fact, it is well to give orthopaedic treatment a year's trial at least. To determine beforehand which roots must be divided for the relief of spasticity a careful examination of the affected limbs should be made to determine the spastic muscles or groups of muscles. Foerster gives the following table as a guide to nerve supply of the lower extremities:

Thigh:	Flexors	L 1, 12, 1–3, 1–4, 1–5, S–1
	Iliopsoas	L–1 to L–3
	Sartorius	L–1 to L–3
	Gracilis	L–2 to L–4
	Tensor fasciæ	L–4 to L–5, S–1
	Extensors	L–5 to S–2
	Adductors	L–2 to L–4
	Abductors	L–5 to S–2
	External rotators	L–5 to S–2
	Internal rotators	L–3 to S–2
Leg:	Extensors	L–2 to L–4
	Flexors	L–5 to S–2
Foot:	Dorsal flexors	L–4 to S–1
	Plantar flexors	L–5 to S–2

[1] Surg., Gynec. and Obst., 1913, xvi, 463.

Foerster states that in severe grades of Little's disease division of the second, third and fifth lumbar and second sacral roots gives the best results. Elsberg states that as the fourth lumbar has to do with extension of the leg it should not be divided and that it is advisable to test with the faradic current the third and fourth lumbar before dividing them to determine which has to do with extension of the leg. Results in the upper extremity are not so good as in the lower. It is usually necessary to resect the fourth, fifth and eighth or fifth, sixth and eighth posterior cervical roots. The results of posterior root section for the relief of spasticity, according to Foerster's table, are as follows:

1. *Root Section for the Relief of Pain.*

44 cases—6 deaths; successful 12, unsuccessful 23, results unknown 3.
Cervical roots, 22.
Thoracic roots, 11.
Lumbar and sacral roots, 11.

2. *Root Section for the Relief of Gastric Crises.*

64 cases—6 deaths; successful 56, unsuccessful 2, no relapse 29; considerable improvement 18, small improvement 9.

3. *Root Resection for the Relief of Spasticity.*

159 cases—14 deaths.
88 cases of congenital spastic paraplegia, 6 deaths.
3 cases of hydrocephalus, 2 deaths.
8 cases of infantile spastic paraplegia.
4 cases of traumatic spinal spastic paraplegia.
1 case of spinal tumor.
1 case of Pott's disease.
6 cases of syphilitic spinal spastic paraplegia.
11 cases of disseminated sclerosis, 4 deaths.
23 cases of spastic arm paralysis, 2 deaths.

S. J. Hunkin[1] reports his experience with 18 operations on 15 patients. The records of 14 patients of this series show: 3 in cervical region (1 for spasmodic torticollis, 2 for Little's disease); 11 in dorsolumbar region (10 for Little's disease, 1 for progressive spinal spastic paralysis). There were 2 deaths in this series: One from shock the cause of the other instance being undetermined. Hunkin summarizes his end-results as follows: All cases were improved, most of them greatly, so far as spasm and general muscular control are concerned. There has never been return of spasm in the abductor groups. Those cases which received better individual training in voluntary movements at home are the ones who show the greatest improvement. Elsberg, Clark and Taylor and others have also reported a reasonable amount of success with this operation. Our own experience has been in keeping

[1] Am. Jour. Ortho. Surg., 1913, xl, 207.

with that of others. In the first case of Little's disease which we operated there was marked improvement following operation. A striking feature of this case was the mental improvement. This has been noted by others and is rather difficult to explain, unless it be that by reason of being able to get around better the intelligence is aroused by wider scopes for observation. Our experience has been disappointing with other types of spasticity. In two instances of traumatic spastic paraplegia there was no improvement, if anything the spasticity was greater after, than before the operation. It has also been the experience of others that improvement following posterior root section was more apt to follow in instances of Little's disease than when done for spasticity due to other causes.

TECHNIC OF RESECTION OF POSTERIOR NERVE ROOTS.

After deciding what roots are to be cut the cord is exposed in the usual way by simple bilateral laminectomy. It is advisable to remove four to six spines and laminæ, for instance, if it is a case of Little's disease in which spasticity of the legs has to be relieved the spines and laminæ of the twelfth dorsal, and all the lumbar vertebræ should be removed. It is necessary to identify the topmost spine and then to mark the skin opposite so that its position may be kept. It is comparatively easy to identify the posterior roots in the dorsal and lumbar region, since the nerves leave the canal opposite to the bottom of the corresponding vertebra. Thus they may be picked up on a small hook as they penetrate the dura, divided near the exit through the dura and about 1 or 2 cm. of the nerve resected. If there should be difficulty in identifying the nerves sought the anterior nerves may be faradized. It will help also to remember that the first lumbar posterior root lies upon a fork of the dentate ligament. The number of roots to be divided will depend upon the condition for which it is done. In general it is better to divide too many than too few. For the relief of gastric crises the sixth to twelfth dorsal roots should be divided on both sides; even this may not be followed by marked relief.

For the relief of pain it is well to divide a larger number of nerves than the number known to supply a given area. Occasionally a single nerve root may be involved; if this is the case, it alone should be divided. After resecting the nerve roots the dura, muscles, fascia and skin are closed in the usual way. Attempts have been made to identify nerve roots at the conus rather than at the exit from the dura (Wilms and Kolb and Elsberg), which have not given satisfactory results, it being more difficult to distinguish the roots by this method.

Guleke advises resection of the roots extradurally after separating the anterior from the posterior roots. It would seem far more difficult to distinguish the posterior roots with certainty extradurally, and for that reason alone it is not to be recommended.

Division of the Anterolateral Tract for the Relief of Pain.—In 1912 Edward Martin cut the antero-lateral tract, at the suggestion of Spiller,

for the relief of severe pain due to inoperable tumor of the cauda equina.[1] This operation was followed by prompt relief, which had lasted a little over one year, the time the patient was last examined. Since fibers conducting pain and temperature sense are found in the antero-lateral column it would seem that, theoretically at least, pain would be more surely abolished by this means than any other. Since it was first proposed it has been done by Beer, Foerster and Elsberg, who agree that it is a valuable addition to spinal cord therapy. The technic of division of the antero-lateral tract requires accuracy on the surgeon's part, as it is easy to damage the pyramidal tract at the same time. It is advisable to divide the tracts in the mid-dorsal region unless the disease extends to a higher level of the cord. The tracts on both sides may be cut, although, as a rule, the pain being limited to one side of the body, it will only be necessary to cut the antero-lateral tract of the opposite side. The cord is exposed by removing the spines and laminæ of two vertebræ and opening the dura. A slip of the dentate ligament is then grasped with forceps, cut free from the dura and the cord raised and rotated by means of traction on the stump of the dentate ligament. A small von Graefe cataract knife, with its cutting edge pointed outward, is carefully introduced into the cord just in front of the dentate ligament, to a depth of about two mm., and brought out just behind the line of origin of the anterior roots. The cord tissue is cut outward. If the cord is penetrated deeper than two mm. the pyramidal tract will be cut. After division of the antero-lateral tract, on both sides if necessary, the dura, muscles, fascia and skin are closed in the usual way. Cadwalader and Sweet[2] in the course of experimental work on the function of the antero-lateral column of the spinal cord, have cut the antero-lateral column, including Gowers's tract, in dogs in order to determine what symptoms would be produced. They concluded that there resulted a definite, though incomplete, loss of cutaneous sensation for pain and for extreme heat and very pronounced ataxia of the hind legs and rump. The fibers whose function it is to conduct painful sensations probably are connected with the thalamus and are situated close to the tractus spinocerebellaris ventralis, whose function is chiefly concerned in the regulation of purposive movements.

[1] Jour. Am. Med. Assn., May 18, 1912, p. 1489.
[2] Ibid., lviii, page 1490.

SURGICAL AFFECTIONS OF THE SPINE AND THEIR TREATMENT.

By FRED H. ALBEE, M.D., ScD., F.A.C.S.

Historical Sketch of Spinal Surgery.—As far back as the Sixth or the Seventh Century, Paulus Aegineta (whose exact dates are not known) is believed to have performed some manner of surgical operation upon the vertebræ. In his treatise on Surgery (Book VI) he advocates incision and "extraction of the compressing bone in cases of *crushing*, or *fracture*, of the vertebral bodies." The first known operation for a fracture of the spine caused by a gunshot injury was performed by Antoine Louis, in 1762. Doubtless, this was only a superficial operation on the arches.

All operations, with exposure of the cord, were fatal until the early half of the 19th Century, when Sir Astley Cooper, in 1823, recommended operation in cases of fractures. Rogers, speaking somewhat in advance of his time, declared in 1835, that "although in all cases of depression of the spinous processes in which an operation has been performed have proved fatal, I think that in a case of simple depression of the spinous process without any injury of the spinal cord, we have a reasonable prospect of success in an operation; at all events, it is the only chance for the patient, and, under such circumstances, I recommend it."

On the other hand, John Ashhurst, as late as 1867, urged against these procedures, proving his point by statistics of fatalities in such cases. Even in 1893, operation in fractures of the spine was denounced by Manley and Cheever. The controversy was hotly waged between the years 1885 and 1890. The growing tendency, however, was toward the employment of operative measures in selected cases. Methods of technic have been improved; the field has widened in the past two decades. Greater possibilities of success have been afforded with the introduction of electrically driven tools, particularly the author's (Albee's) electro-operating outfit.

Surgical Affections of the Vertebral Column.—The following disorders of the spine and their surgical treatment will be considered in this discussion:

I. Tuberculosis of the Spine.
II. Non-tuberculous affections of the spine.
III. Static deformities of the spinal column.
IV. Traumatic affections of the vertebral column.
V. Affections of the Sacro-iliac joint.

TUBERCULOSIS OF THE SPINE.

(POTT'S DISEASE; SPONDYLITIS TUBERCULOSA.)

Percival Pott, in 1770, gave the first accurate description of this condition, which is accompanied by pain, and sometimes by paralysis. The cause of this slowly developing deformity was not, however, definitely ascertained, until 1882, when Koch discovered the *tubercle bacillus*. The term, as used today, does not include such cases of angular deformity as may result from fracture, erosion of an aneurysm, syphilis, malignant disease, or other pathological processes. It is confined, rather, to those cases of kyphosis in which deformity is due to tuberculous infection of the vertebral bodies. The angular deformity, which is characteristic, is produced by the compression and disintegration of these bodies of the vertebræ.

Incidence.—*Age-incidence*, from a broad interpretation of statistics, is shown to be most frequent at about the age of five years. This is primarily a disease of early childhood, as is borne out in the following table from Whitman, in which over 85 per cent. of the cases occurred in children under ten years of age:

AGE-INCIDENCE IN POTT'S DISEASE (1259 CASES, WHITMAN).

Age period.	Number of cases.	Incidence, per cent.
Under 1 year	38	3.1
From 1 to 2 years	176	14.2
3 to 5 "	627	50.2
6 to 10 "	234	18.3
11 to 20 "	89	7.2
21 to 30 "	43	3.5
31 to 50 "	31	2.6
Over 50 years	11	0.8

Sex seems to play no role in the etiology of Pott's disease, although boys appear to be slightly more frequently afflicted than girls.

The spine is a more common location of tuberculous disease than any other single joint or bone. *The relative frequency* is strikingly shown in the following table of cases of tuberculosis recorded at the Hospital for Ruptured and Crippled (New York City), from the year 1885 to 1904:

Location of tuberculous disease.	Number of cases.	Per cent.
Spine	4299	39.6
Hip	3329	30.7
Other joints, incl.	3222	29.7
Total number of cases	10,850	

Predisposition.—Statistics vary as to the hereditary factor in Pott's disease; in one instance, a positive family history has been found in only 10 per cent.,[1] while, on the other hand, Gibney reported tuberculous parents in 76 per cent. of his series of cases.

[1] Jaeger and Waterman: Tr. Am. Orth. Surg., xiv, 287.

Frequently there is history of trauma, particularly of a fall. Often, no doubt, the injury may be purely imaginary, or injury may be specially noted on account of sensitiveness caused by the preëxisting tuberculous condition.

Normal Anatomy of the Spine.—Twenty-six superimposed bones, or vertebræ, compose the vertebral column; seven of these are cervical, twelve thoracic, five lumbar, with the coccyx and the sacrum.

"Viewed in profile, the normal spine has four anatomical curves: two with their convexities forward in the cervical and lumbar regions, and two with their convexities backward in the thoracic and sacral regions. The upper three curves merge imperceptibily into one another, but the lumbosacral junction presents a marked angle, prominent on the anterior surface of the column at the sacral promontory. Viewed from behind, the vertebral column is vertical." Abnormal exaggerations of these antero-posterior curves and deviations from the normal vertical plane may give rise to Scoliosis (lateral deviation), Kyphosis (posterior convexity), or to Lordosis, in which case the convexity is ventral.

TABLE FROM AMERICAN TEXT-BOOK OF ANATOMY—SHOWING THE CHARACTERISTICS OF TYPICAL VERTEBRÆ OF EACH GROUP.

	Cervical.	Thoracic.	Lumbar.
Bodies . . .	Small; transversely elongated; sloped downward and forward; lipped laterally; no costal facets	Heart-shaped; deeper behind; nearly equal transversely and antero-posteriorly; costal facets	Large; elongated transversely; no costal facets.
Pedicles . . .	Pass outward and backward; notches above and below nearly equal	Pass backward; inferior notches deeper than superior	Pass backward and slightly outward; inferior notches deep.
Laminæ . . .	Long, slender, flattened	Broad, short, imbricated	Short, deep and thick.
Spinous processes	Short, strong bifid and nearly horizontal	Long projecting downward and overlapping	Quadrate, horizontal, of medium length.
Transverse processes . . .	Short, slender, directed outward and forward	Long, strong; projecting outward and backward; articulate with tubercles of ribs	Rudimentary, as "accessory process."
Costal process	Slender, flat, ossified to the vertebra and transverse process	A separate bone (*i. e.*, a rib)	Ossified to vertebra; flat, thin, "transverse process."
Superior articular processes . .	Flat; directed upward and slightly backward	Flat, directed backward and slightly outward	Slightly concave; directed inward and slightly backward.
Inferior articular processes . .	Flat; directed downward and slightly forward	Flat, directed forward and slightly inward	Slightly convex; directed outward and slightly forward.
Spinal foramen .	Large, triangular, wide	Smaller, circular	Larger than in the thoracic; triangular; wide.

A *typical vertebra* consists of a *body*, with a *neural arch* posterior to it completing the *spinal foramen*, of which the entire series form the

vertebral canal. The neural arch has two *pedicles,* two *laminæ* and seven *processes,* of which two are *transverse,* four *articular* and one *spinous.* The pedicles contain *vertebral notches,* above and below; this series constitutes the *intervertebral foramina.* The *laminæ* are expansions from the pedicles; they become fused behind in the midline, and at this junction they are prolonged into the *spinous processes.* The *transverse processes* are outward expansions from the junctions of laminæ and pedicles. The *articular processes* consist of an upper and a lower pair, which extend from the roots of the transverse processes; they articulate with the like processes of the vertebræ above and below.

There are two sets of articulations of the vertebral column: (1) those between the bodies, which are *amphiarthrodial,* and (2) the *arthrodial* (gliding) joints which are between the articular processes and are connected by ligaments. "The *intervertebral disks* between the bodies consist of an external fibrous portion and an internal pulpy, elastic portion, with a central synovial cavity. The *anterior common ligament* is a strong band lying over the anterior portions of the vertebral bodies, and extending the entire length of the spinal column, being continued above as the *anterior occipito-atlantal* and *anterior atlanto-axial ligaments,* and below as the *anterior sacrococcygeal ligament.* Its function is partly to limit extension of the spine. The *posterior common ligament* lies on the dorsal surfaces of the vertebral bodies and extends the length of the spinal column, continuous above with the *posterior occipito-axial ligament.*"

The *arthrodial* or *gliding joints* between the articular processes contain, each, a synovial cavity.

The neural arches are united by the following ligaments: (1) the *ligamenta subflava,* which connects the laminæ of the adjacent vertebræ from axis to sacrum; (2) the *interspinous ligaments,* extending between the adjacent borders of the spinous processes; and (3) the *supraspinous ligament,* a continuous ligamentum over tips of the spinous processes, of which the *ligamentum nuchæ* is a continuation above.

Bloodvessels supplying the vertebral bodies and neural arches are the spinal branches of the vertebral arteries. Intricate plexuses within and without the spinal canal are formed by the veins.

Pathological Anatomy.—The tuberculous process is most frequently located in the *body* of the spine, and the vertebræ usually involved are the eighth to twelfth dorsal.

The following table (from Whitman) shows the location of the disease in 1355 cases of tuberculous spondylitis recorded at the Hospital for Ruptured and Crippled:

Location of tuberculous disease.	Number of cases.	
Cervical vertebræ	100	
Dorsal vertebræ	854	
Lumbar vertebræ	317	
Lumbosacral vertebræ	13	
Total	—	1284
No deformity		55
Disease in two regions		16
Total number of cases		1355

The incidence of involvement of the vertebræ, according to location of disease, would seem to increase steadily from the first cervical vertebra (with 3) to the maximum (120) at the twelfth dorsal vertebra, thereafter showing a progressive decrease. The infectious material, carried by the blood-stream finds lodgment, setting up the tuberculous process usually in the body. Of all varieties, the *central* is by far the most common. Other forms include the *epiphyseal variety*, in which the process may begin at the epiphysis of the body, next to the intervertebral disk, extending into body and disk; *anterior variety*, in which the disease may be located in the anterior part of the body, just posterior to the anterior common ligament; and, *rarely*, the *appendiceal variety*, in which the transverse processes are the seat of the disease.

FIG. 340.—Tuberculosis of the spine and of the right hip, of unusual character. Flexion deformity of the hip gave rise to lumbar lordosis of such severity that the skin over the gluteal muscles was brought into firm contact with that over the kyphosis of the lower dorsal spine from the point indicated by the arrow backward to the tip of the kyphos.

Gross Changes.—The essential pathological process is always very much the same in all varieties of Pott's disease. The central type is the variety most frequently encountered, and the following description (taken from Albee's *Orthopedic and Reconstruction Surgery*) may be regarded as typical of the process:

"As a result of obliterating endarteritis consequent upon tuberculous

toxemia, the primary change is a disturbance of nutrition of the vertebral body. The marrow changes from red to a pale myxomatous structure, making an ideal soil for the growth of the tuberculous follicle. These follicles increase in size, coalesce, and central caseation occurs. The gray myxomatous marrow of early malnutrition has now a different aspect; the central yellow caseous area is surrounded by a gray zone limited by a thin peripheral shell of red congested marrow.

FIG. 341.—Rontgenogram of the dorsolumbar spine, showing the bodies of the vertebræ *B* and *C* completely obliterated and one directly above and below thinned and wedge-shaped due to the tuberculous process. The resulting kyphotic angle of the spine thus produced should be noted. The principal feature, however, of this rontgenogram is that no repair by bone proliferation is shown, although the destructive lesion in this case had existed for not less than three years. The need of the implantation of bone is apparent.

The lamellæ become rarified, and varying degrees of absorption occur. If they become isolated before absorption is completed, they form sequestra.

"A striking phenomenon during the elaboration of the tuberculous focus is the constant tendency of the marrow to become fibrous. There is probably never any subperiosteal new bone laid down, except in the late stages; tuberculosis seems to inhibit its formation, in contrast with the formation of subperiosteal new bone in all other infections. With the centrum of the vertebral body caseous, the superimposed weight

of the spinal column is now borne only by the fragile peripheral shell of compact bone. With the fulcrum (articular processes) and the long arm of the lever (pedicles, laminæ and transverse processes) intact, and the short arm (body) diseased, the latter gives way and descends; while the long intact arm ascends, causing the tips of the spinous processes to be widely separated, and produces the angular deformity in the back as a *kyphosis*. The leverage action is aided and the deformity increased by over-action of the irritated anterior muscles lying on each side of the spine."

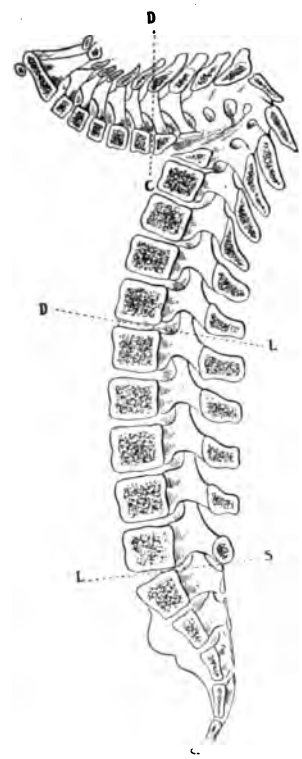

FIG. 342.—Destruction of the bodies of the third, fourth, fifth, sixth and seventh dorsal vertebræ; partial destruction of three others. (Ménard.)

Gross changes associated with the kyphosis, which is the characteristic deformity in Pott's disease, are compensatory curves and lateral deviations of the spinal column, as a whole, as well as structural changes in thorax and pelvis and frequent abnormalities of the heart and great vessels. The extent and character of the kyphosis depends largely upon its location and upon the number of vertebræ involved. The angularity is sharp in case of the involvement of only one vertebra. The dorsal prominence is rounded when several vertebræ are diseased and the deformity is liable to be great. Moreover, a rounded kyphosis denotes chronicity.

In the *cervical region*, the deformity is slight; inflexion of the spine

to any great degree is prevented by the base of the pedicles. Hyperextension of this region of the spine is possible on account of the large space between the posterior arches. In the *dorsal region* occur the most severe deformities of all, largely because the physiological curve is posterior. In the *lumbar region* the kyphosis is never marked, since the extensive intervertebral space between the bodies and the wide intervals between the laminæ and spines of adjacent vertebræ readily permit of hyperextension. There is, however, some shortening of the spinal column in this region.

Compensatory spinal curves take place; in *cervical disease* there is a dorsal curve with a change in the axis of the head; *cervical* and *lumbar lordosis* appear in *dorsal disease*; and in *lumbar disease* there is hyperextension of the hips.

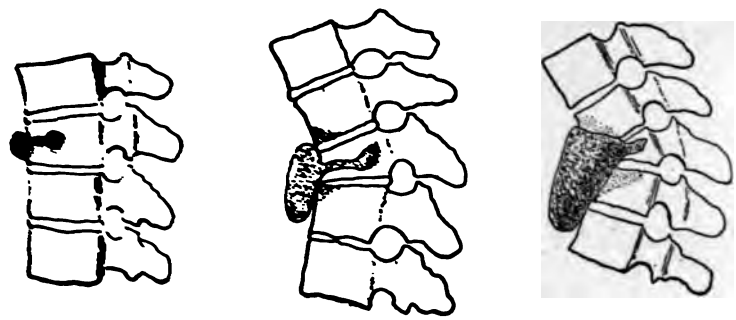

FIG. 348.—Tuberculosis of the spine, showing the progressive disintegration and collapse of the vertebral body primarily affected, the infection of the contiguous vertebræ by contact, and the mode of production and growth of a prevertebral ichor pocket (cold abscess). (After Calot.)

Lateral curvature of the spine often resembles non-tuberculous scoliosis. In some cases it complicates kyphosis. It is caused by collapse of the vertebral bodies, when the upper rests in an oblique plane upon the underlying vertebra; and by unilateral disease of the bodies.

Even in cases of great deformity, symptoms from bony pressure are uncommon in the spinal cord and meninges. *Paraplegia* may be caused by disease of the vertebræ, the meninges or the spinal cord.

Rarely bony compression by the vertebræ occurs, which is occasionally caused by partial dislocation from trauma or by pressure of sequestra. It is almost always due to the encroachment of tuberculous granulations or to an ichor pocket (cold abscess). Tuberculous perimeningitis may occur by extension of the disease, followed by pachymeningitis, and ultimately by leptomeningitis. Involvement of the cord by tuberculosis is rare. The infection is usually secondary, and the cord in this event may become constricted by pressure. There may be local edema and subacute myelitis and softening of the cord.

The heart is very likely to be affected in Pott's disease of the mid-dorsal region. The base is displaced downward, the apex upward, and the heart may be rotated on its horizontal-transverse axis. Hypertrophy results from kinking of the aorta, with resulting constriction

and dilatation of the left ventricle. The aorta is likely to become kinked at the center of its transverse portion, and also directly opposite the kyphosis. The *vena cava* becomes distorted in a like manner.

FIG. 344.—Lumbar Pott's disease; the posture indicates that the disease is still active. (Taylor.)

Thoracic distortion in Pott's disease is described by Tubby, as follows: "In the chest three varieties of deformity are seen: (*a*) If the curve is *high up* in the *dorsal* region, the true ribs are held at an angle greater than the normal; the sternum is displaced downward and the antero-posterior diameter of the thorax is diminished. In fact, the chest is in an expiratory position. (*b*) If the disease is *low down* in the *dorsal region*, the ribs and sternum are raised, the antero-posterior diameter of the chest is lengthened and the chest is barrel-shaped and is in the position of inspiration. Therefore, the breathing is diaphragmatic and the patient is short of breath. (*c*) When the *lumbar region* is affected, the whole thorax sinks downward and forward, the lower

ribs override the pelvis, the ensiform cartilage approximates to the symphysis pubis, and the abdominal wall is thrown into folds."

Pelvis distortion occurs compensatory to the kyphosis in the lumbodorsal and lumbosacral segments. In *lumbodorsal Pott's disease*, tilting of the sacrum takes place, the upper part backward, the lower part forward; broadening of the iliac crests; increase of the anteroposterior and transverse diameters of the pelvic inlet; diminution of the pelvic outlet by encroachment of the lower half of the sacrum; approximation of the ischia; the pelvic cavity becomes funnel-shaped. In *lumbosacral involvement*, rotation of the sacrum takes place similar to that in lumbodorsal disease, and the pelvic outlet is, thereby, diminished owing to encroachment of the lower half of the sacrum; coincidently, the lumbar lordosis is diminished and in some cases entirely obliterated.

Ichor Pockets (Cold Abscesses).—It should be borne in mind that a circumscribed collection of tuberculous ichor (from disintegration of bone and soft tissues and exudate from granulation tissue) in no manner resembles the pyogenic product likewise termed as "abscess." An *ichor pocket* (cold abscess) is the most frequent complication of Pott's disease, being found in 20 per cent. of all cases according to Townsend.[1] The name, suggested by A. Rose, and first used by H. L. Taylor, designates tuberculous fluid débris.

The ichor gravitates from its point of origin, directed by the planes of fascia and other neighboring anatomical structures. The course of ichor pockets originating from Pott's disease, is given as follows, according to spinal regions:

1. In the *cervical region* the direction in which it gravitates is controlled entirely by the arrangement of the deep cervical fasciæ. Gravitating between the anterior surface of the cervical vertebræ and the prevertebral fascia, it bulges forward as a retropharyngeal ichor pocket; or it may spread laterally to the posterior edges of the sternomastoid muscles. It may penetrate the prevertebral fascia, appearing high (in the mouth) or low down (in the visceral compartment of the neck, around the esophagus and trachea); but frequently it gravitates downward to the mediastinum or axilla, or it may slough into the esophagus. It may become located between the spinous processes and ligamentum nuchæ on the inner side, and the posterior cervical muscles on the outer side.

2. In the *dorsal segment* of the spine, a collection of ichor is nearly always small in amount and is usually retained *in situ*. Between the vertebral body and the anterior common ligament (prevertebral) it remains *in situ*. Penetrating the anterior common ligament, it gravitates into the posterior mediastinum. Extending laterally as it gravitates, it may lie beneath the pleura or perforate it, thus forming a tuberculous empyema. Gravitating downward, it may appear in the lumbar region. It may follow the intercostal vessels. It may follow the nerve trunks along the external or internal branches of the posterior primary divisions.

[1] Tr. Am. Orth. Assn., iv, 164.

3. In the *lumbar region* the course of an ichor pocket is directed by the psoas, iliac and lumbar fasciæ, lumbar arteries and nerves. Follow-

FIG. 345.—Bilateral lumbar abscess. (Whitman.)

ing in the sheath of the psoas muscles, beneath Poupart's ligament, it presents itself at the inner or outer side of the femoral vessels. Guided by the sheath of the psoas muscle for a short distance, it then passes outward under the fascia iliaca to appear in the iliac fossa; or it may perforate the sheath of the quadratus lumborum and appear in Petit's

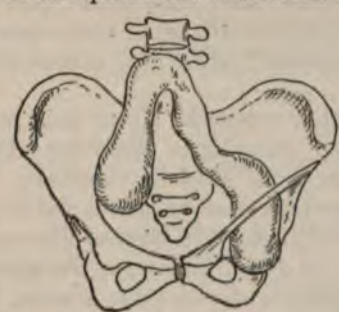

FIG. 346.—Psoas abscesses (ichor pockets), as originating from lumbar Pott's disease and gravitating downward in the psoas muscle sheaths. (After Calôt.)

triangle. It may gravitate behind the aorta, downward with the great bloodvessels and follow the external iliac artery to point in the pelvis.

It may perforate the rectum, or follow through the great sacro-iliac foramen. Sometimes it follows between the planes of the abdominal muscles and appears in the anterior abdominal wall. It may follow the dorsal branches of the lumbar arteries and appear near the last rib and the spines.

Amyloid degeneration (Waxy degeneration, or lardaceous disease) is a frequent complication of bone tuberculosis with sinuses. Secondary infection complicating tuberculosis is the cause of about one-half of all the cases. From a pathological standpoint this is an infiltration, and not a degeneration, characterized by deposit of amyloid, a glycoprotein, between the visceral cells, particularly those of the liver, kidneys, spleen and the bloodvessels of the mucosa, more especially of the intestines. The usual cause is prolonged suppuration; therefore, joint tuberculosis complicated by a secondary pyogenic infection is frequently followed by this condition.

Fibrosis is Nature's method of cure and not by a regeneration of bone. This is a phenomenon in striking contrast to the process of repair in the osseous lesions of the other infections (typhoid, pyogenic, etc.). This has been abundantly shown by the *x*-ray, and offers one of the chief arguments in favor of immobilization by operative means.

Rare forms of tuberculosis of the spine include tuberculous disease of the occipito-atloid and atlo-axoid articulations (spondylarthritis), of the transverse processes, spinous processes, costovertebral articulations and joints of the articular processes.

Symptomatology.—A careful inquiry should always be made into *family history* for *hereditary tendencies* to tuberculosis; the most minute details of the patient's present illness should be noted, recording symptoms in order of their appearance, and a complete physical examination should be made with the patient's clothing entirely removed. Rarely the first symptom obtainable in spinal disease is kyphosis or beginning paraplegia. As a rule, however, "a more or less extensive *complex of subjective symptoms* precedes their physical signs." Occasionally during the convalescence from one of the exanthemata, indefinite symptoms of debility are noted. Lassitude, poor appetite, slight loss of weight with some nocturnal rise in temperature may be the only symptoms. This *prodromal period* may extend over several weeks or even months.

Pain is either local or referred. Local pain may be subjective, or elicited. It is sharply stabbing in character and occasionally corresponds to the location of the involved vertebræ. Referred pain is distributed in the region of the sensory nerves and it is generally subacute with periodical exacerbations. In *cervical disease,* pain is referred to the occiput and arm; in *dorsal disease,* to the sternum, or it is present as intercostal neuralgia; in *dorsolumbar disease,* it is referred to the epigastrium and there are girdle pains; in *lumbar disease,* pain is referred to the hips and the legs. The skin of these regions is apt to be hypersensitive. Referred pains are frequently the cause of a mistaken diagnosis in early caries of the spine, especially in epigastric pain where *indigestion* is often the mistaken diagnosis. Night cries are not so

frequent as in the case of the larger joints. They are usually present in the cases of cervical and dorsal disease.

Paralytic Symptoms.—Difficulties in going up and down stairs and a shuffling gait, etc., suggest the beginning of pressure on the cord and of paralysis, which is spastic in nature, with no involvement of the sensory nerves.

Symptoms due to the ichor pocket may occur in certain segments. In the *cervical* there may be dysphagia, hoarse voice, or dyspnea. In the *upper dorsal* (ichor pocket points anteriorly) there are dyspnea, and voice changes due to pressure on the recurrent laryngeal nerve. In the *lower dorsal* and *lumbar* (ichor pocket in iliac fossa with psoas contraction) difficulty in walking may be a symptom. "A peculiar grunting respiration is not unusual. In addition, cough is not uncommon, also dyspnea, gastric disorders, flatulence, obstinately recurring vomiting and disorders of the bladder."

Careful examination of the patient should be made. This should include not only a complete physical examination, but the use of the x-ray in every instance to determine the exact location and extent of the disease and to confirm the diagnosis. Physical signs should be observed, as follows:

The attitude is one of apprehension from fear of jarring the sensitive spine; anticipating an unexpected movement, the patient flexes all the joints of the body except the spine which he holds rigidly; this attitude is the so-called "spring type." Thorough observation as to gait, attitude and movements should be made before and after stripping the child. Caries of the spine of a particular region is characterized by a specific attitude, so typical that to an experienced surgeon, the disease may almost be located solely by a study of this sign. The following classification of postures according to spinal region is taken from Albee's *Orthopedic and Reconstruction Surgery:*

Location of disease.	Attitude.
Upper cervical	Resembles wry-neck, but there is usually no rotation of the face.
Lower cervical	Head thrown back and to one side. Chin forward.
Upper dorsal	Shoulders raised. Shoulders and arms thrown back ("military style"). Upper chest flat. Lower chest prominent.
Middorsal	Spinal rigidity and early deformity. Arms appear longer and hang down more than normal. Globular thorax. Ribs tilted up. Sternum forward.
Dorsolumbar and upper lumbar	Typical attitude; head and upper body back; abdomen prominent, patient stands on a broad base with feet wide apart—"alderman's gait" (belly out, chest and shoulders back, waddling).
Last lumbar vertebra	Tuberculous spondylolisthesis (destruction of body of last lumbar vertebra, with displacement forward and downward of the lower part of the spine). Attitude: Very marked lordosis of the back with projection of the abdomen. Thorax depressed—last rib nearly touches iliac crest; deep transverse abdominal fold at level of umbilicus.

General Appearance and Physical Condition.—The patient is liable to have the facies of general tuberculosis, but with the added element of pain causing an expression of anxiety. However, in some instances, the general health seems good. Poor bodily nutrition and low weight are the rule.

Spinal distortion should be investigated with the patient standing and always stripped, at least as far as the waist. The most frequent deformities are: dorsal kyphosis (already described under pathology); obliteration of the normal anteroposterior curves ("boarding") and lordosis.

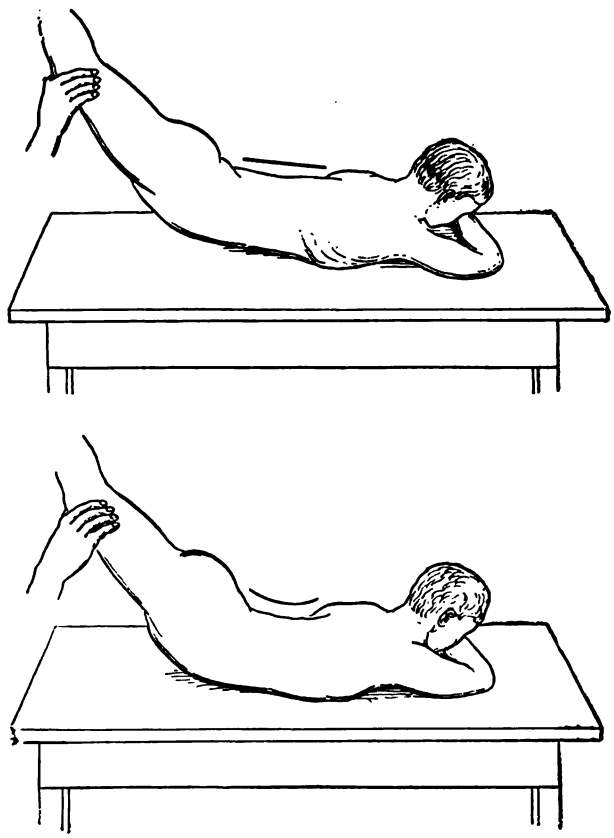

FIG. 347.—Shows extensibility of the spine in a normal individual. Upper figure illustrates the muscular rigidity ("boarding") of the back on passive extension of the spine.

Lateral curvature sometimes complicates *kyphosis* and is often mistaken for an ordinary scoliosis. In cases of "boarding" the anteroposterior curves are obliterated, the spine is sometimes almost straight. This phenomenon is caused by muscular rigidity and represents Nature's attempt to immobilize the spine. *Lordosis* is the compensatory curve for kyphosis, and varies in location according to the segment of spine involved. In *cervical* disease lordosis is absent, being represented by a decrease or obliteration of the normal dorsal kyphosis. In *dorsal*

disease, the compensatory lordosis is found in varying degrees in the lumbar region. In lumbar disease the lordosis may be diminished or nearly obliterated with hyperextension of the hips.

Recording the Deformity.—A graphic measure of the degree of the deformity, from time to time, should be made for future reference. A satisfactory method consists of the use of a strip of malleable lead tape (18 inches x ½ inch x ⅛ inch) which is molded over the kyphosis, the result obtained being traced on paper.

"Possibly a more rapid record can be made with Young's apparatus. The instrument consists of a wooden bar with a slot in which a number of wooden uprights of equal length play. By means of an adjustable screw fixed in one end of the bar, the wooden uprights can be released and, when their ends are placed against the spine, adjust themselves to the outline of the deformity, when, by tightening the screw, this outline is retained and can be transferred to paper."

a *b* *c*

FIG. 348.—The three usual causes of parlysis in Pott's disease: *a*, Dislodgment of a disintegrated fragment of vertebral body and pressure therefrom upon the cord; the same effect would be produced by posterior dislocation of the entire vertebral body (both causes rare). *b*, The escape of an ichor pocket into the epidural space and compression of the cord between it and the neural arch. (*c*) Pachymeningitis caused by extension of infection from the subjacent osseous lesion. (After Calôt.)

The following method or recording lateral curvature is described by Fraser: "A strip of netting about 18 inches long and 4 inches wide is used. The netting has a half-inch mesh, and running lengthwise along the spine a colored line is marked. The material is held along the spine in such a way that the median line lies exactly in the center of the body as judged by the seventh cervical vertebra and the natal cleft. The line of the scoliosis is marked upon the netting with ink."

Of all the physical signs of Pott's disease, muscular rigidity is the most characteristic. Tuberculous toxemia and Nature's efforts to guard the diseased vertebræ stimulate muscular rigidity, restricting the normal spinal movements in a manner more or less peculiar to the three segments, as follows:

In the *cervical region*, the normal movements are free flexion, extension and lateral flexion throughout this region, "nodding" at the occipito-atlantal articulation and rotation at the atlanto-axial joint. Restriction of these movements is tested in children in the following manner:

FIG. 349.—Cervical disease. A characteristic attitude. (Whitman.)

FIG. 350.—Attitude of head in cervical Pott's disease. (Bradford and Lovet

Active Movements.—With the child prone on the table or lap, face down, limitation of normal flexion is observed by failure of the child to "hang" its head forward. Limitation of extension is tested by turning the child on its back and observing its inability to drop the head backward. In very young children, suddenly attract the patient's attention to a bright object at some lateral point, to observe rotation. *Passive movements* consist of manipulation of the head, taking care to guard against tearing the transverse ligament of the atlo-axial articulation when the disease is high up.

In the dorsal region all four movements may be made normally. Of the *active* movements, the *flexion* test is the most important. The patient stands erect and the tips of the spinous processes are marked. He then bends forward, when there occurs *no increase* in the distance between these processes, as is normally the case. On attempting to take an object from the floor, the joints of the knees are bent instead of the back. In the case of the *passive movements*, the patient lies prone upon the table, with the elbows flexed and arms at the side. The legs are then raised by lifting the ankles, and the very exaggerated lordosis which normally follows this maneuver is entirely obliterated, on account of the stiffness of the back.

In the *lumbar region* examination is accompanied by the same stiffness of back, as well as diminution of the normal lordosis.

Sinuses and Ichor Pockets.—The following regions should be examined for scars of old fistulæ and sinuses, and for the presence of ichor pockets: triangles of the neck, posterior wall of pharynx, loins, iliac fossa, Scarpa's triangles and inguinal regions. Mediastinal prevertebral ichor pockets may be well shown by the *x*-ray, while ichor pockets in the psoas sheath must often be inferred, if not palpable, by the spasmodic shortening of the psoas muscle.

From the study of an extensive number of statistics, *paraplegia* associated with caries of the spine appears to occur in from 5 to 6 per cent. of the cases of tuberculous spinal disease. This complication is far more often seen in the upper and mid-dorsal segments. The paralysis is motor in type and, as a rule, affects the lower extremities. The bladder and rectum are sometimes involved. Paralysis is spastic and varies with the extent of involvement of the cord. The distribution of the paralysis depends upon the location of the disease. The lower limbs and sometimes the sphincters affected in cases of *low dorsal and lumbar* disease; in *cervical* disease, the arms are involved before the legs; in *dorsal* disease there is spastic paralysis of the legs, but no involvement of sphincters. In *high cervical* disease, the diaphragm is affected and likewise the spinal accessory and hypoglossal nerves.

Careful investigation of all nerve functions should be made. *Motor disturbances* are indicated by jerky movements, ataxic gait, dragging of toes and stumbling. Among the *sensory disturbances* are pain of limbs and body, disturbance of cutaneous sensibilities and exaggeration of reflexes. There may also be incontinence of urine and feces, pressure sores, muscular atrophy, vasomotor disturbances and *rare*

signs typical of nerve involvement, as flushing, dilatation or contraction of pupil, etc.

Head, Thorax and Pelvis.—Any abnormal posture of the head, contour of thorax and direction of the ribs, or pelvic distortion, should be observed. The following summary of signs and symptoms, grouped by regions, is taken from Albee's *Orthopedic and Reconstruction Surgery:*

A. *Upper Cervical Disease:*
   1. Difficulty in moving head; muscular spasm.
   2. Local pain over spine.
   3. Referred pain in back of head, and along upper cervical nerves.
   4. Pain upon pressing the vertex.
   5. Limitation, or abolition of "nodding" and rotation of head.
   6. Deformity resembling wry-neck.
   7. Obliteration of suboccipital hollow.
   8. Head supported in hands, on account of great pain.
   9. Ichor pockets, retropharyngeal, or suboccipital.
   10. Cord symptoms; dislocation of the head, if odontoid process is disintegrated, is followed by sudden death; the usual paralysis of arms, then of legs.
   11. Ankylosis at site of lesion usually follows a cure.

B. *Cervical and Cervicodorsal Disease:*
   1. Marked rigidity, associated with wry-neck, shortening and angular kyphosis.
   2. Thorax: ribs vertical; anteroposterior diameter reduced.
   3. Pain, which follows branches of cervical or brachial plexus.
   4. Ichor pocket; retropharyngeal, supraclavicular, or mediastinal.
   5. Cord symptoms not so common as elsewhere; arms first then legs.

C. *Dorsal and Dorsolumbar Disease:*
   1. Characteristic kyphosis; muscle spasm.
   2. Localized vertebral thickening.
   3. Spondylolisthesis.
   4. Pelvic deformity, funnel-shaped in children.
   5. Pain, radiated to outer side of thighs.
   6. Neuritis, local distribution.

Nerve Pressure Symptoms:
   1. Pupillary symptoms, myosis or mydriasis, from pressure on the sympathetic.
   2. Recurrent laryngeal and vagus symptoms, as cough, slow pulse, vomiting, etc.
   3. Characteristic attitude; head and body turned as one to look at an object.
   4. Grunting breathing from pressure upon intercostal nerves.

Diagnosis.—With a kyphosis present, no difficulty is encountered, as a rule, in making a diagnosis. The most puzzling cases are, however, those of compression symptoms without a kyphotic deformity. A history of referred pain, particularly epigastric or sternal, is suggestive.

The following signs are strongly indicative of Pott's disease: *muscle-spasm, ichor-pocket formation* (often sudden) and *early spastic paralysis*, which may be the initial sign. A differential diagnosis is given in the following table, taken from Albee's *Orthopedic and Reconstruction Surgery:*

DIFFERENTIAL DIAGNOSIS.

	Disease.	Points of resemblance.	Points of difference
Cervical region	Torticollis	Abnormal posture of head and neck	No pain on motion; shortened sternomastoid muscles; rotation of face to opposite shoulder; hemiatrophy of face; *x*-ray; cervical spine flexible.
	Torticollis due to acute arthritis of cervical spine following acute infection	Abnormal posture of head and neck, rigidity, pain on movement, etc.	Acute history; rapid subsidence under treatment; *x*-ray; metastatic infection from tonsillitis, etc.
	Round shoulders with stiffness	Stiffnes causes restricted motion; absence of pain (adolescent tuberculous spondylitis)	No muscle spasm; *x*-ray negative; long duration; postural history; absence of neuralgic pain.
	Fracture or dislocation cervical vertebræ	Torticollis; kyphotic deformity with stiffness and weakness; pain; paralysis	History of the injury with acute symptoms follow. *x*-ray.
	Typhoid spine	Pain, weakness and stiffness of the neck	Typhoid history with onset in its later stages, *x* ray.
	Arthritis deformans with or without cervical kyphosis	Pain and stiffness in neck	Chronicity; relief from recumbency at night, marked difference in *x*-ray findings.
	Sarcoma	Local pain; paralysis; deformity	Rare in childhood, all symptoms more severe, palpable tumor paralysis [illegible] quick and early, *x*-ray.
	Hysteria	Pain and stiffness in back and neck	Pain does not follow nerve distribution, with several points of tenderness over thoracic spine other hysterical symptoms, *x*-ray
Dorsal region	Rhachitis	Kyphotic deformity	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]

	Disease	Points of resemblance.	Points of difference.
Dorsal Region	Spinal neuralgia	Pain in the back	Pain more diffuse and over a large part vertebral column, is more superficial and more acute; rigidity entirely absent; subjects are neurotic young girls; *x*-ray.
	Anatomical anomalies	Abnormal prominence of one or more vertebral spines, resembling a kyphosis	Physical examination negative except for the pseudokyphos; *x*-ray.
	Typhoid spine	As in cervical region.	
	Arthritis deformans	As in cervical region.	
	Sarcoma	As in cervical region.	
	Hysteria	As in cervical region.	
	Gonorrheal spondylitis	Pain, weakness, stiffness of back	Rare; ankylosis common; urethral discharge stops when spinal involvement begins; *x*-ray.
	Paralysis:		
	Diphtheritic	Attitude. Localized. Muscular weakness	History of diphtheria with symptoms following. Absence of symptoms of spinal caries.
	Cerebral spastic paraplegia	Spastic condition of the muscles; gait; reflexed increased	Absence of pain; history; mental impairment; absence of symptoms of spinal caries.
	Cerebrospinal meningitis	Contractions, weakness and pain; reflexes increased	History of the case; meningitis with symptoms following.
	All the preceding dorsal spinal affections		
Lumbar Region	Hip-joint disease	Limp (psoas-contraction); flexion of the thigh	Limp usually late symptom; no spinal symptoms; pain on functional use; all motions at hip limited.
	Sacro-iliac disease	Pain and sensitiveness of lower spine	Pain and tenderness *localized* at joint; movements of spine not restricted; uncommon in childhood; great restriction of motion of hip.
	Perinephritic and perityphlitic abscesses	Motions of spine restricted; swelling in inguinal region; contraction of psoas muscle	Acute onset; constitutional disturbances; local tenderness; voluntary spinal restriction; preceding history; positive findings on spinal, abdominal, urinary and *x*-ray examination.
	Strain of back	Stiffness and pain on motion	Sudden onset; cause known; pain localized at point of injury; relieved by test; restriction of motion voluntary.
	Pseudohypertrophic muscular dystrophy	Attitude; weakness or lordosis	Absence of pain, kyphosis and muscular rigidity; extremely slow onset; gait waddling awkward (years); knee-jerks diminished or lost.
	Lumbago	Stiffness and pain	Sudden onset; local pain; sensitive *muscles;* uncommon in childhood.
	Sciatica	Pain referred to legs (both)	Pain *unilateral* and confined to distribution of the nerves which are sensitive to pressure; movements of legs painful, spine painless; uncommon in childhood.

Prognosis.—The *outlook* as regards life is good, except in cases of infants under two years of age. The latter cases offer a very unfavorable prognosis. The *age limit* was found to average forty-nine and a half years by Neidert, in 1886, limitation being due to intrathoracic conditions, usually cardiac, with distorted aorta and great bloodvessels. *Causes of death* are meningitis, acute miliary or pulmonary tuberculosis, amyloid infiltration of liver, kidneys, or spleen and exhaustion.

FIG. 351.—Albee's broad thin osteotome for splitting the spinous processes of the spine in preparing the graft bed in the spine.

The *extent* of the *permanent deformity* depends upon the condition of the vertebral bodies when first observed, and the promptness of the treatment, and its character. If the kyphosis is plastic, early complete fixation of the spine by the inlay bone graft almost invariably prevents further deformity, and, in many cases, has obliterated an already existing deformity in young subjects. Gibney found that 77 per cent. of the paralyses complicating Pott's disease were cured or improved by conservative methods. The prognosis after operative treatment

is more favorable. In unoperated cases, recurrence after a real, or apparent, cure is frequent.

The *duration of treatment* varies with the type of procedure. Treatment by the old conservative and time-consuming methods of external mechanical supports is in marked contrast to the expediency and success of treatment by Albee's method of inlay bone-graft fixation.

Treatment.—The same principles of *general treatment* apply in Pott's disease that are fundamental in the treatment of all forms of tuberculosis of the bones. Heliotherapy, as directed by Rollier, should be employed. Nourishing food should be plentiful. Cod-liver oil and tonics should be used freely.

"From time immemorial the object of all local treatment of tuberculous vertebræ has been to secure immobilization of the affected region of the spine, to the end that Nature might repair the lesion by substituting fibrous connective tissue for the carious vertebral bodies. In the past, attempts were made to secure this result by various mechanical supports whose name is legion. Principally because of the large size of the trunk and the fact that it includes within it two important functionating organs, the respiratory and gastro-intestinal organs, which are in constant motion and cause a continual change in the diameter of the thorax and abdomen, no effectual immobilization of a part of the spine is possible of attainment by means of indirect supports (plaster jackets, frames, braces, jury masts, etc.).

"By recognizing the absolute necessity of complete localized fixation of the affected vertebræ directly at the site of the disease, and by devising and elaborating a method of securing it, the author believes that he has revolutionized the treatment of Pott's disease and has substituted for external supports a rational, scientific, surgical procedure which effectually locks the involved segment of the spine, allowing Nature to relieve the situation in a comparatively short time and, in favorable cases, without the production of deformity. As the structure of the bodies of the vertebræ is made up almost entirely of spongy bone, and as tuberculous disease in bone is confined almost entirely to this cancellous bone structure, it follows that this portion of the vertebra is involved to the exclusion of the denser or vertical portion, *i. e.*, the lateral masses and spinous processes."

"As the action of each vertebra in the spinal column is for the most part a leverage action, and as the superincumbent body weight is borne in very large measure by the individual bodies of the vertebral column with their interposed intervertebral cartilaginous disks, it follows that as respiratory action and involuntary contraction of the abdominal muscles, together with the activity of the tuberculous focus, weakens the resistance of the bodies to weight-bearing and these bodies are crushed and disintegrated, and unless measures are taken to prevent this crushing and to transfer the weight-bearing more upon the articular processes and lateral masses, this crushing effect continues and the vertebral column collapses forward at the expense of the anterior arms of the levers (the vertebral bodies) causing a separa-

tion of the posterior arms of the levers (the spinous processes) thus producing the increasing angular deformity, or kyphosis, so noticeable in these cases."

Albee's procedure has been devised on the basis of this principle of the leverage action of the vertebræ, in order to prevent the increase of this posterior angular deformity. The arrest of the tuberculous process depends largely upon the ability to check this increasing kyphosis and prevent further collapse of the vertebral bodies. As can be readily seen, any external fixation applied to the series of levers of the spine as a whole, cannot be so exact in its control of any segment thereof as a fixation applied directly to the leverage action of the particular vertebræ involved. Thus we can compare the inexactions of the plaster jacket with the direct fixation of the bone-graft. The means adopted to bring about this arrest of increasing deformity also relieves the other symptoms accompanying the disease, pain, involuntary muscle spasm, general weakness and the characteristic awkwardness of attitude. The methods heretofore employed to accomplish this have been: (1) *Recumbency*, which removes one of the chief exciting factors, namely the superincumbent weight of the body. This must be maintained during the activity of the destructive process. (2) *The application of plaster-of-Paris jackets or braces*, either as a further means of fixation during or following the months of compulsory recumbent treatment on a gas-pipe frame or, as it is employed by many, in conjunction with a certain amount of rest in the recumbent posture from the time the lesion is discovered, the so-called ambulatory treatment."

"Nature, in her endeavor to protect the spine when attacked by tuberculosis, resorts to immobilization of the diseased area by the means at her command, and, by fixing the attached spinal and abdominal muscles in involuntary spasm, accomplishes this immobilization to a certain degree; but in so doing, in spite of external supports, usually increases the crushing effect of the diseased vertebral bodies with increasing collapse of the spine, which together with the added influence of respiratory motion usually results in extensive kyphosis and disability. As Nature has taught us that immobilization is the prime factor in arresting tuberculous osteitis, we have endeavored to substitute for Nature's method our artificial fixation in an attempt to prevent the disfiguring and crippling angular deformity and progress of the disease; but as conservative brace methods offered the means to only approximately accomplish this end, many cases continued to develop increasing deformity and complete invalidism, and succumbed to this debilitated state."

"It is the exception and not the rule for cases of Pott's disease treated by the conventional methods of externally applied fixation, to produce a solid bony union between the partly destroyed vertebral bodies, and when actual firm bony fixation is not accomplished the case cannot, as a rule, be considered permanently cured. As has been pointed out by many men dealing with tuberculous osteitis of the

adult bone, it is always essential to secure a strong bony ankylosis in order to arrest and permanently cure tuberculous lesions where actual bone destruction has taken place. This rule applies more strongly to the vertebræ than to other articulations."

"With such examples of ineffectual control of this progressive tuberculous disease constantly in evidence, further efforts were made to provide more accurate fixation of the tuberculous spine. Appreciating the leverage action of the vertebræ and failures to arrest the disease by external appliances, actual surgical intervention by wiring together the spinous processes (posterior lever arms) of the diseased vertebræ with silver wire was tried; but as the fixation for the cure of this condition must continue for a long period of time, and as silver wire, being a foreign material, causes absorption of the bony structures in which it is placed and pulls through and drops out by its own weight, especially in the presence of constant respiratory motion, the resulting fixation is sure to be lost soon."

The method employed by Albee to bring about the desired ankylosed condition of the segments of the spine consists of the implantation of one continuous strip of bone (preferably from the tibia) of sufficient length to span the diseased vertebræ and to include also one lumbar or two healthy dorsal vertebræ above and below those involved. The tibial graft is inlaid into a gutter previously made by splitting the ligamentous and spinous processes in order to receive the long bone-graft between their broken halves.

"In conjunction with the above mentioned observations, the increased trustworthiness of the bone-graft, especially in small children, is still further emphasized by the fact that broken or incised cartilage tends to heal by the formation of bony callus and that the implantation of a bone-graft into the cartilage also influences the transformation of cartilage into bone." Therefore, Pott's disease may be considered as a distinctly *surgical affection*, and one in which operative treatment should be given the preference over all therapeutic measures. Mechanical treatment should be employed only in the postoperative care, or in cases of patients who refuse to undergo operation, or are not surgical risks.

Local treatment may be considered under the four headings: *Operative, Mechanical, Treatment of Deformity* and *Treatment of Complications.*

Operative Treatment.—I. *Albee's Bone-graft Fixation of the Vertebræ.*—The technic of preparing the graft-bed, together with the removal of the graft and its implantation (described in Albee's *Orthopedic and Reconstruction Surgery*) is, as follows:

(*a*) *Incision.*—"This is semilunar in shape, usually about 6 to 8 inches in length, begins well above the site of the lesion, swerves in a wide sweep to one side of the midline at the level of the diseased vertebræ, and returns to the midline where it ends well below the diseased area. By having the free edge of this semilunar skin-flap away from the site of operation, the engrafted structures are guarded from contamination in the event of skin or suture infection.

(*b*) *Exposure.*—"After dissecting up and reflecting the skin-flap the tips of the spinous processes lie directly exposed. Hemorrhage, usually slight, is best controlled by compression with towels wrung out of hot saline solution. A small amount of serous exudate and blood is considered advantageous to early nourishment of the graft.

(*c*) *Preparation of the Graft-bed.*—"The supraspinous ligament is split into equal halves longitudinally over the tips of the spinous processes with a scalpel. The interspinous ligaments are treated likewise. Muscular and ligamentous attachments to the spinous processes must be disturbed. With the author's broad, thin, sharp osteotome (1½ inches wide), its cutting edge parallel with their tips, the spinous processes are split in halves to a depth of ⅓ to ⅔ of an inch nearly down to the neural arches. One-half of each spinous process, always on the side, is fractured completely at its base and set over a distance varying according to the thickness of the graft which is to be implanted. Care is taken not to break the remaining spinous process halves and to preserve their full leverage action. Bleeding should be checked by ligatures or hot saline compresses.

"The graft bed thus prepared presents a median longitudinal gutter, on one side of which are the cut surfaces of the *unbroken* halves of the spinous processes (with the cut surfaces of the bisected supra- and interspinous ligaments with their osseous attachments undisturbed), and on the other side the cut surfaces of the *fractured* halves of the spinous processes (with their corresponding bisected ligaments attached). It is to be noted that the muscular and ligamentous attachments are undisturbed save for the splitting, fracturing, and spreading incidental to bisection of the spinous processes. This leaves the antero-posterior diameter of the spinal column undiminished and unweakened, and preserves the full leverage activity of the spinous processes as posterior arms of the vertebral levers.

"It should be constantly borne in mind that the spine is a composite of a series of levers, each one of which has its short (anterior) arm, the vertebral body, and its long (posterior) arm, the spinous process. The length and shape of the required graft is determined by calipers and a flexible probe applied to the gutter bed, and the latter is protected by a hot saline compress, tightly packed, awaiting the preparation of the graft.

(*d*) *Removal of Graft.*—"The patient being in the prone position, the prepared leg is raised and flexed to an acute angle with the thigh. A skin incision is made along the antero-internal surface of the tibia, sufficiently long to allow a generous exposure of the tibia for the removal of the graft and so placed that its closure will not bring the skin sutures over the bone cavity produced by removal of the graft. The skin is dissected up from the periosteum (but the latter is not disturbed), and the muscles freed from their attachments to the outer side of the tibial crest.

"The size and thickness of the graft required depends upon the segment of the spine to be immobilized and the amount of strain

required of the graft. In general, it should include the total thick of the tibial cortex (periosteum, endosteum, and marrow), an width should be three to four times this amount. Using the m probe as a pattern rod, the required graft is obtained by incisin periosteum with a scalpel. The lower three-fourths of the an internal surface of the tibia is selected on account of its strong cortex.

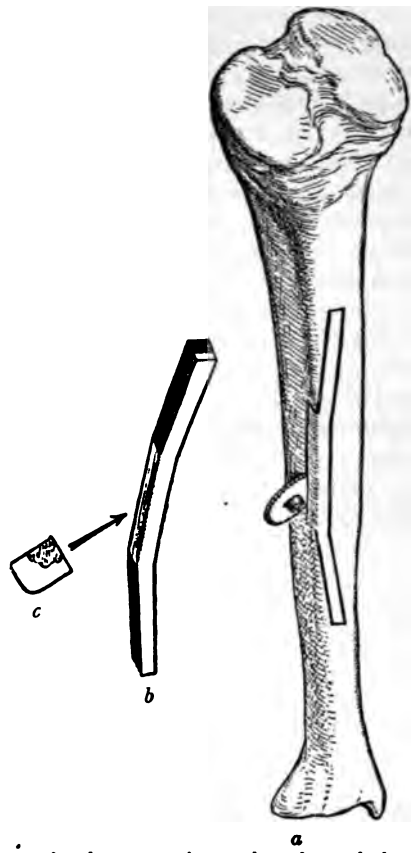

FIG. 352.—*a*, Saw-cuts in the antero-internal surface of the tibia for obtai moulded graft; *b*, a longitudinal view and *c*, a cross-section of the same at its central portion. (Albee, "Bone-graft Surgery.")

"If the graft is to be straight, it is best removed from the crest, enough to encroach upon the antero-internal surface, so as to fu the width required. If it is to be molded for a moderate kyphosis central or fulcrum portion of the curved graft includes the crest o tibia and from this portion each end is cut obliquely upward and d ward on the antero-internal surface of the bone. The advanta this graft lies in the dense thick cortical bone which forms its ful portion and which constitutes the strength of a lever (graft). Sh angular kyphoses and those of short duration, particularly in chil

are amenable to varying degrees of correction. In molding the graft, its pattern should be the shape of the gutter-bed *after* correction has

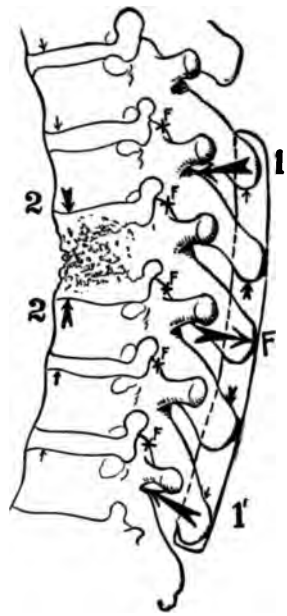

FIG. 353.—Each vertebra is a lever with its fulcrum point at small *F*. The arrow on the vertebral bodies at *2*. *2* Indicates lines of force from weight bearing, involuntary muscle spasm, etc., influencing crushing of vertebral bodies and progress of deformity by the approximation of the anterior lever arms. Which is associated with an equal separation of the spinous processes or the posterior lever arms. This is prevented by a pull lengthwise on the graft as indicated by the small arrows situated at each spinous process. The graft in respect to this direction of force is under a great mechanical advantage. (Albee, "Bone-graft Surgery.")

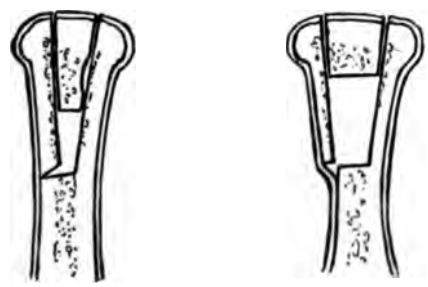

FIG. 354.—*A* illustrates a cross-section of a spinous process split in half, and fractured at its base. The deep, thin graft in the cross-section has been removed from the crest of the tibia, having its periosteum attached to two sides. The side in contact with the unbroken half of the spinous process is the saw-cut, or the medullary surface of the graft. *B* illustrates a cross-section of a spinous process which has been split and one-half has been set over to produce a gap sufficient to receive a broad graft removed from the antero-internal surface of the tibia, having periosteum on one surface only. The medullary surface of the graft lies nearest the base of the spinous process in the gap. (Albee, "Bone-graft Surgery.")

been applied by manual pressure on either side over the lateral masses, when the probe is then bent into the clefts of the split spinous processes.

"To obtain the straight graft, the tibial cortex is cut through to the marrow cavity with the motor circular saw, following the periosteal outlines of the pattern; this includes a saw-cut just to the outer line of the tibial crest and at a right angle to the one previously made on the antero-internal surface. This cut must be made the whole length of the graft, if a straight one; and if a molded one, only to include the middle or fulcral portion. At either end, beyond the central or crest portion, the graft overlies the marrow cavity and the saw cuts, therefore, need be made only on the antero-internal surface to free the graft."

"The graft is freed by cross-cuts at each end, made with a very small motor saw. It is then loosened and pried out by a thin osteotome introduced into the longitudinal saw-cuts. Although a thin chisel and

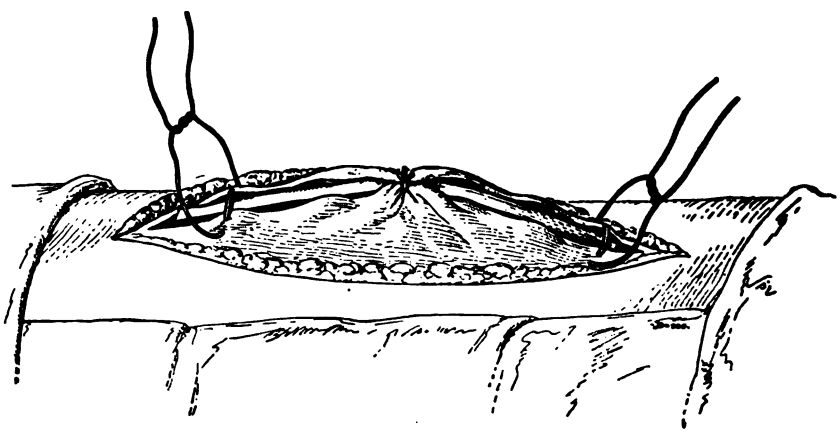

FIG. 355.—Molded graft for Pott's disease in place with the kangaroo-tendon sutures in process of being inserted. (Albee, "Bone-graft Surgery.")

mallet may be used to remove a bone-graft, the motor-saw has a very distinct advantage, particularly in the case of very dense brittle bones in adults, where the tibia and the graft are easily cracked with mallet and chisel. Other disadvantages of the latter are traumatism of the graft, inaccuracy of molding, and postoperative pain in the leg. The graft is immediately transferred from the tibia to its spinal bed, all unnecessary handling being avoided and clamps used instead of the operator's fingers for its transference. The cutaneous incision in the tibia is at once closed by an assistant with a continuous suture of No. 1 plain catgut and the wound properly dressed, while the operator proceeds at once to mold and implant the bone-graft.

(*e*) *Inlaying the Graft.*—"In case the graft is straight, it is held in place by a strong suture of kangaroo tendon passed though one-half of the split supraspinous ligament at one side of the gutter, thence up over the graft at its central portion, and out through the opposite

split half of the supraspinous ligament. Upon tightening and tying this suture, the two halves of the slit supraspinous ligament are approximated over the central portion of the graft. The extremities of the graft are then secured in like manner. The sutures should be passed deeply enough to get a firm hold upon the ligament and close to the spinous processes (either above or just below them) to obtain the most intimate contact possible between the graft and the raw surfaces of the bisected spinous processes. In some instances, in order that the supraspinous ligament and the fascia lateral to it may yield and completely cover the graft, it is advisable to place the sutures in the ligament midway between the spinous processes or at a varying distance to the side of them. This ligament, in the lumbar region especially, (particularly in adults) may be so dense and tense as to require incision of the lumbodorsal fascia on either side just external to the line of sutures, to allow its being drawn together to cover over the thick graft.

"In every instance the graft must be long enough to include the spines of two healthy vertebræ above and two below the diseased area. It must be constantly borne in mind that on account of the natural obliquity of the spinous processes in certain regions (particularly the dorsal), the fact that their tips are well below the horizontal planes of their corresponding bodies (*x*-ray appearance) may mislead the operator into cutting the graft too short to include the requisite number of healthy spines or placing it too low in the spine. A satisfactory roentgenogram should always be obtained, not to confirm the diagnosis but to serve as a guide in inserting the graft.

"Before fixing the ends in position, their sharp corners are removed by rongeur forceps and the fragment is placed about and under the graft ends before the latter are secured with sutures. The removal of these bone fragments from the ends of the graft on its posterior edge-surface with a rongeur cutter causes it to be roughened so that it is better held and thus prevented from springing backward by the ligaments sutured over it. These fragmented particles furnish added foci for bone proliferation and enhance the amalgamation of the graft ends and the contacted spinous processes, on the principle that the osteogenetic power of the bone-graft is in inverse ratio to its volume as emphasized by Macewen, that is, the smaller the graft, the greater is its relative surface and the more active its bone-growing ability. It has been further demonstrated that, because of their size, small grafts obtain their nourishment more readily from the surrounding serum or blood. The rest of the graft is then secured with kangaroo-tendon sutures, placed at half inch intervals throughout its length and tied in the manner above described."

"In case the graft has been cut on the *curved* pattern, it must be placed *on edge* in its bed in order to fit the kyphos; its periosteal surface lies to one side and its marrow surface to the other. It should be so placed that the *marrow* surface shall be in contact with the side of the gutter formed by the unfractured halves of the spinous processes; the *periosteal* surfaces contacting with the fractured halves. The *endosteal*

(marrow) surface being more actively osteogenetic, is thus in contact with the more virile unfractured half of its host. The curved graft is secured in exactly the same manner as the straight graft.

"If a straight graft with transverse saw-cuts (made on its marrow surface $\frac{2}{3}$ to $\frac{3}{4}$ through its thickness) is to be bent, it should be obtained from the lower two-thirds to three-fourths of the antero-internal surface of the tibia where the cortex is thick and includes the crest or not, at the discretion of the operator. If the graft does not include the crest, the twin saw hastens its removal and insures its uniform width

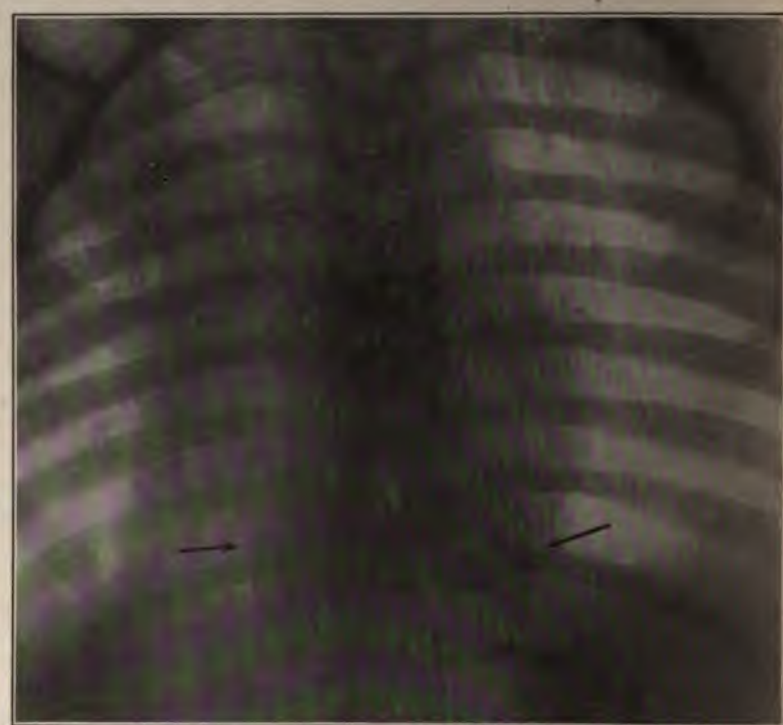

FIG. 356.—Showing large mediastinal abscess of lower dorsal region in a child aged five years. Following the insertion of a bone graft, it slowly absorbed and disappeared, as shown by frequent roentgenographic examination.

throughout. If it includes the crest, cuts at right angles to each other on each side of the crest are necessary. In the latter case, the graft includes two periosteal surfaces and is therefore more active osteogenetically and stronger mechanically. It is again emphasized that *every graft should include all bone elements, namely, periosteum, compact bone, endosteum, and marrow substance.* This is the author's bent-in graft and, as the saw-cuts naturally weaken it, the molded graft previously described should always be used when possible.

"In making the transverse saw-cuts to allow the graft to bend (as a carpenter cuts his board to cause it to bend about a curved surface)

FIG. 357.—Roentgenogram, showing bone-graft fixation of spine for Pott's disease in case of a child aged five years. This case, seen by the author in consultation with T. Halsted Myers, proved to be one of the most acute cases of tuberculosis of the spine that the author has ever seen. The patient had been under the care of a very excellent orthopaedic surgeon who had not succeeded in controlling the symptoms by any known conservative means, such as plaster jackets, spinal braces, Bradford frames, etc. For some months the child had been immobilized by a well-fitted spinal brace (Taylor's), supplemented by recumbency in the dorsal position upon a Bradford frame. In spite of this most rigorous treatment, however, active symptoms had continued uncontrolled, with periodical attacks of violent vomiting which was apparently a reflex phenomenon resulting from the uncontrolled spinal condition. This seemed all the more certain after the more adequate spinal fixation by bone graft later, when the attacks of vomiting subsided entirely. The classical operation of Albee for the treatment of Pott's disease was performed by the author, the bone graft (indicated by arrows, *A–B*) being taken from the child's left tibia. Following operation, the patient made a very splendid convalescence, although the acuteness of the symptoms demanded great conservatism. The child was kept in the recumbent position in bed for about three months, followed by an application of a Taylor spinal brace which was worn for about six months. The child continued to improve, and is at present completely recovered, with splendid function of the spine, and without any deformity, as is indicated by the arrows, *C–D*, which designate the original site of the disease. He is an active boy aged eight years, who enjoys the same games, and is quite as energetic, as any of his playmates.

the graft is held securely by the operator with two strong clamps, one at either end. An assistant holds the motor firmly on the instrument table with the saw over-hanging its edge. The current (under the operator's control by means of the foot-switch) is turned on. The operator presses the graft up from below against the rapidly revolving saw. By holding the graft in this way, he can regulate the spacing and

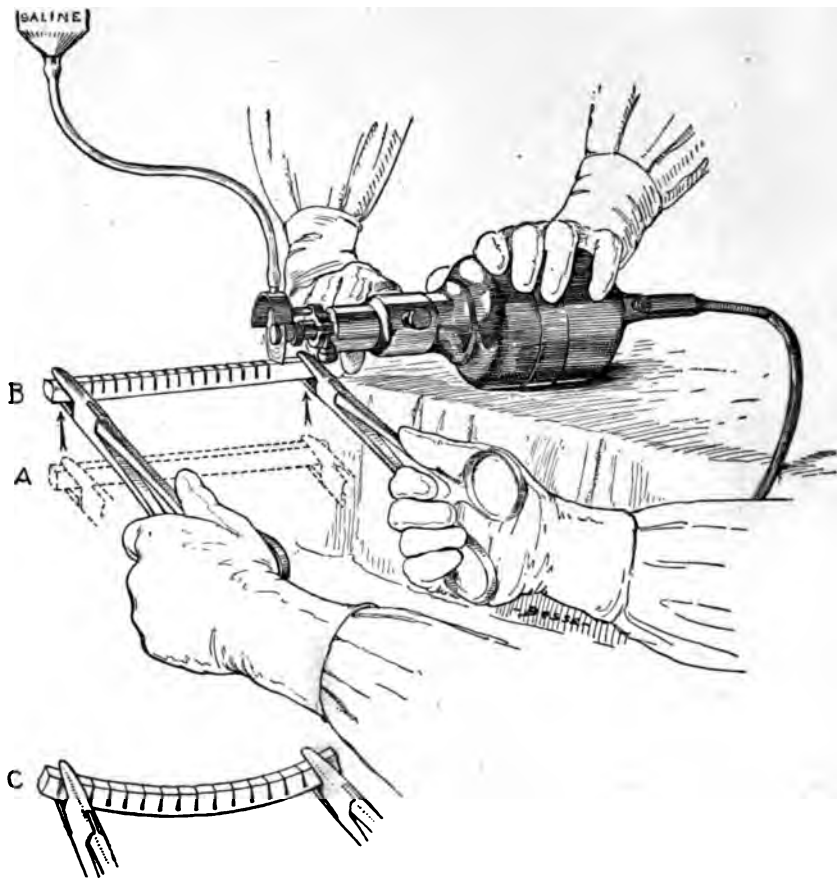

FIG. 358.—*A*, The manner of holding the graft while making the transverse saw-cuts to increase its flexibility. *B*, Transverse saw-cuts at equal intervals and three-quarters through the diameter of the graft on its marrow surface. *C*, Testing for the desired amount of curve in the graft obtained by making the transverse saw-cuts before applying it to the kyphosis of the spine. (Albee, "Bone-graft Surgery.")

depth of the cuts along the marrow surface, and can test its flexibility and judge very accurately when he has rendered it sufficiently flexible to conform to its bed and span the deformity, without being obliged repeatedly to place the graft in its bed to determine this point. The proper guard (washer) adjusted to the saw regulates the uniform depth of the cuts and by eliminating the danger of entirely severing the graft, permits operative speed.

"The bent-in graft is laid in its bed with the medullary surface (containing the saw-cuts) downward (anteriorly), its periosteal surface

FIG. 359.—Ligature has been tied over first spinous process. First long graft is being held down by assistant. Second long graft is being inserted on top of first and into cleft of second spinous process. Second ligature is about to be tied to hold second long graft in place. The process is repeated until all clefts are filled. (Albee, "Bone-graft Surgery.")

upward (posteriorly), and its edges in contact with the cut surfaces of the gutter side and the split spinous processes. In other words, the bent graft is not placed between the split spinous processes edgewise, but with its wide diameter laterally.

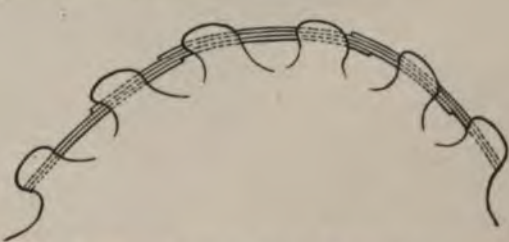

FIG. 360.—Diagram showing how grafts are disposed in complete operation. ("Bent-shingle" technic.) (Albee, "Bone-graft Surgery.")

"*Suturing* is performed as in the case of other grafts, except that the bent-in graft is firmly sutured first at one end and the middle, the other

end projecting free. This freely projecting half is slowly bent by consecutive suturing from the central point of the graft to its projecting end, thus obviating the danger of fracture, which might occur if it were

FIG. 361.—Lateral roentgenogram of a spine of a man, aged twenty-two years, which is illustrative of the extreme degree to which an adult tibial bone-graft can be bent. *C* indicates the saw-cuts in the marrow side of the graft. This case had been under conservative treatment seventeen years as a private case by two very competent orthopaedic surgeons; nevertheless, a relapse with paraplegia occurred after that period of treatment. The result after the insertion of the bone-graft was immediate and excellent.

first held bent in place by one embedding suture at each end while the other sutures were added. Whether or not fracture occurs, it is well to reinforce this graft by placing along each of its sides, at the maximum point of curvature thin strips of cortical bone cut with the motor-saw from the tibia where the graft was obtained.

(*f*) *Closure.*—"The skin wound is closed in the usual way, and sterile dressings are applied. Thick pads of gauze and cotton, varying in thickness according to the degree of the kyphosis, are placed on each side of the grafted area to prevent pressure-sores on the apex of the grafted kyphosis. The dressings and pads are then secured in place by broad strips of zinc oxide adhesive plaster. It is not safe, even with this dressing, to allow patients with a prominent kyphosis to lie upon the back; they must be restrained upon the side, or obliquely on the back during the postoperative recumbent period."

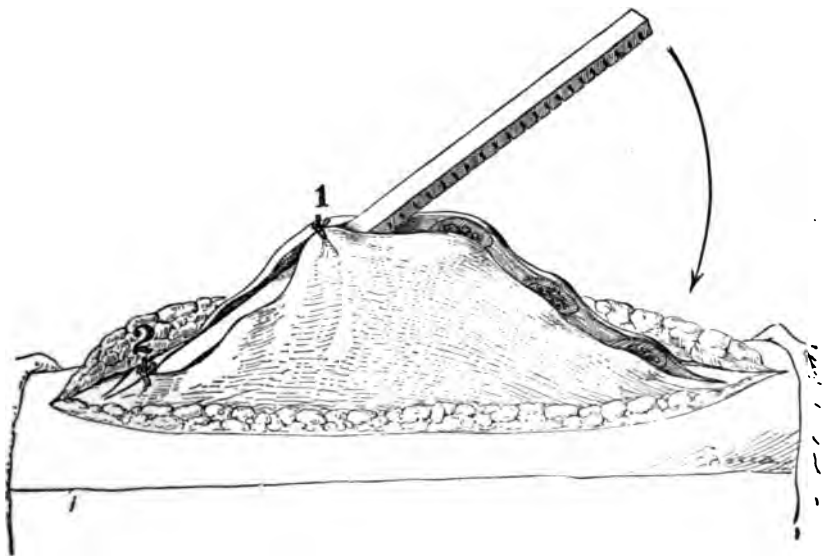

FIG. 362.—Method for children of securing the bent-in bone-graft to adapt it to the curve of the kyphosis. *1*, First fixation suture; *2*, second fixation suture. The arrow indicates the direction which the graft is to be bent to fit over the kyphosis. (Albee, "Bone-graft Surgery.")

Albee's Bent Shingle Technic of Spinal Inlay.—In cases of a sharp, angular kyphosis, or an extended one, the following procedure has been devised by the author: "The graft-bed in the spinous processes is prepared, as has already been described. The leg is given the customary preparation and the incision in it is made in the usual manner. With the single motor-saw, two cuts, each about six inches in length, are made in the antero-internal surface of the tibial cortex, one close to the external, the other close to the internal limit of the medullary cavity, to produce anoci-association.

"With the single saw, the intervening cortex is now cut into strips, each about one-sixteenth to one-eighth of an inch in breadth. These

strips are released by the small cross-cut saw. One of the strips is cut in equal halves, one of which is laid, on the flat, in the spinal gutter at the lower extremity of the kyphos. One of the long thin strips of bone is then placed, its lower half being exactly superimposed on the short piece, the remainder projecting. Upon this projecting end, another long thin strip is placed in a similar manner and this procedure is repeated with each of the strips, just as a carpenter shingles a roof.

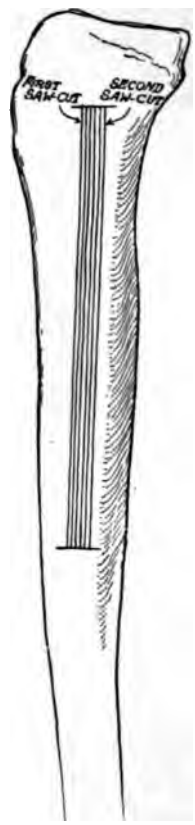

FIG. 363.—To show grafts obtained for the author's "bent-shingle" method of placing grafts over a large kyphosis in children or adults. The saw-cuts labelled first and second are made first so as to produce nerve blocking (Crile's anoci-association) of the intervening strip of bone before it is sawed into 5 or 6 strips of bone $\frac{1}{12}$ to $\frac{1}{8}$ inch thick and 3 to 5 inches in length. (Albee, "Bone-graft Surgery.")

Care must always be taken that each succeeding 'shingle' overlies not only the projecting end of the preceding one but also about one-third of the undermost one, in other words, so that there will be three thicknesses of bone strips at each point of junction. When the upper extremity of the kyphos has been reached, the short half-piece of bone strip (its other half having been used to start the 'shingling' process) is slid beneath the last two 'shingles' that were laid.

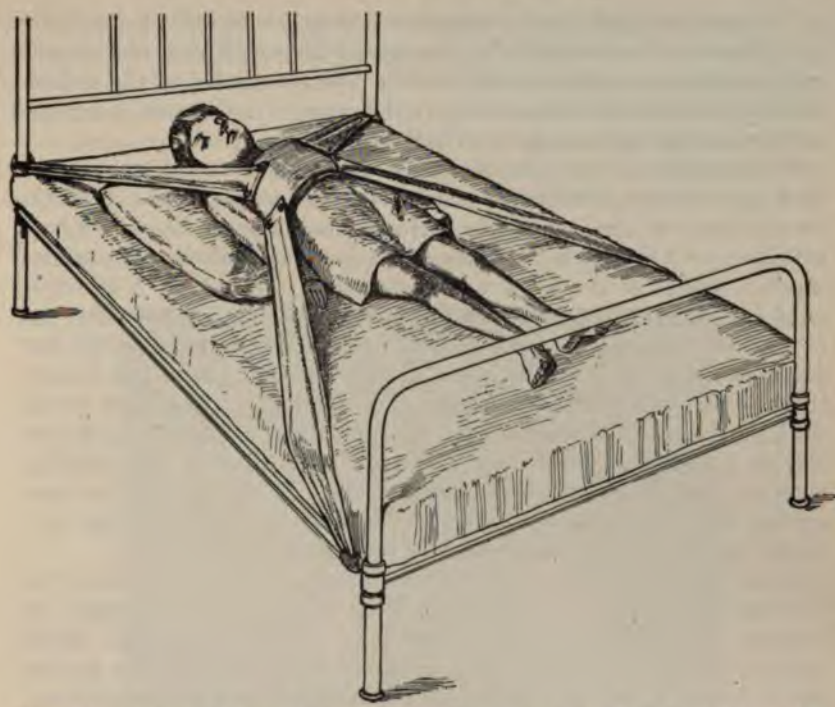

FIG. 364.—Method of fixation in bed after the bone-graft implant for Pott's disease has been applied. (Albee, "Bone-graft Surgery.")

FIG. 365.—Pott's disease of third and fourth cervical vertebræ (at *D*) with almost complete paralysis of the right arm. The graft *AB* was inserted with immediate relief of all symptoms, including the paralysis of the arm, in ten days' time. C indicates small grafts. (*Albee, "Bone-graft Surgery."*)

"Sutures of small-sized kangaroo-tendon are passed through the spinal ligament at the points of junction of three 'shingles' and at such other points as seem to be indicated. The remainder of the technic and the postoperative treatment are the same as in the author's spinal inlay operation, previously described."

Postoperative care in favorable cases consists of recumbency upon the back on a fracture-bed for at least five weeks for adults, and six weeks for children. In the case of the latter, immobilization is secured by a towel, or binder, pinned about the trunk from the axilla to the anterior superior spines of the ilium and fastened to the bed by four broad muslin bandages attached by one end to the binder and by the other end to the four corners of the mattress. This holds the patient in the flat dorsal position and prevents his sittings up or rolling from side to side. In the event of a marked kyphosis, it is advisable, in addition to the thick pads already in position, to keep the patient secured in the lateral oblique position in order to prevent undue pressure on the skin-flap overlying the graft with resulting necrosis. The author also advises against use of the gas-pipe frame with its rigid canvas covering, or a plaster jacket during the immediate postoperative period.

While the foregoing method of treatment in no wise removes the diseased focus, which is anatomically impossible, it does secure the requisite immobilization of the individual vertebræ affected. Relief of symptoms may, in many cases, be immediate; however, the patient should follow for many months the proper régime of physiological rest, nourishing diet, fresh air and sunlight. Adults should always avoid any sort of laborious work for at least six months after operation.

Children should have one year, or more, of restraint, with out-of-door-life and regulated periods of daily rest.

External supports to the spine are especially recommended in cases where the patient is obliged to be moved from the bed before expiration of the six-weeks postoperative period, or in cases in which the graft has bent or become weakened on account of the transverse saw-cuts made in molding it to the marked kyphotic curve or in young children or in any doubtful case. In such instances, a plaster jacket should be worn for a few months.

The foregoing technic is applied when implanting a bone graft into all regions of the spine. The anatomical variations of the spines of the different segments should be borne in mind, as well as the increased strain in the various segments. The strain placed on the graft, when inserted in the thoracic region, for instance, is much less than from the midthoracic region to the sacrum. In the lumbar region the general leverage bearing upon the graft will include not only the weight and force applied through the whole extent of the spinal column above the inserted graft, but likewise the force of the leverage action from muscle-pull of that portion of trunk and lower limbs which extends below the graft. A kyphosis of any extent is rarely found in this segment and a straight graft can generally be used.

Summary.—By the bone-graft operation, the full leverage action of each vertebra is not only preserved, but is utilized to the fullest possible degree in preventing the crushing of the vertebral bodies anteriorly, due to superimcumbent body-weight, respiratory motion, contraction of the abdominal muscles and various attempts at normal movements, by the fixation of the graft ankylosed into the spinous processes. Furthermore, the *accurate immobilization* of the involved segment of the vertebral column is accomplished without any interference with respiratory or digestive functions, or body movements,

FIG. 366.—This roentgenograph shows the satisfactory proliferation of a bone-graft inserted six months previously for tuberculosis of the fifth lumbar vertebra. The graft was contacted with the third and fourth lumbar vertebræ above and the first and second sacral segments below the lesion.

and without resorting to long-continued recumbency, or to mechanical means of external fixation, such as braces, gas-pipe frames, and the like.

The inlay spinal bone-graft is indicated in *all cases* and at *all ages* in which pain or muscle-spasm require it. The earlier the operation, the more promising is the outlook. It is especially recommended for prevention and correction of increasing deformity. The only contra-indications are high fever, pyogenic bacteremia and a septic field of

operation. The presence of an ichor pocket, which rarely occurs in region of the spinous processes, is not a contra-indication to operat On several occasions, the author has placed a graft through an ic pocket with satisfactory union of graft following.

The prognosis following a bone-graft operation is very promi as regards relief of symptoms and, in suitable cases of children, decr of the deformity. Results in incipient stages in adults have

FIG. 367.—Acute Pott's disease of the lower thoracic region with large psoas abscess, four years after the insertion of a tibial graft. The abscess immediately disappeared and the patient has not lost a day's work on account of his back since seven weeks after the operation.

FIG. 368.—Case of acute Pott's d operated during the first year o disease when there was a very kyphosis.

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FIG. 368.—Case of acute Pott's disease operated during the first year of the disease when there was a very small kyphosis.

exceedingly gratifying; relief of symptoms and arrest of the degenerative process have usually occurred in the more chronic cases. In refutation of the contention made by some that the bone-graft operation in children produces deformity and that healing by cartilage takes place, the author has obtained abundant evidence from clinical and roentgenographic observations that the growth of the graft keeps pace

with the rest of the spine in these cases. It should, also, be remarked that any tendency to the development of lordosis in these cases of bone-graft fixation is counteracted by the tendency of the spine to curve in the opposite direction (kyphosis). The outlook is, of course, strongly influenced by the postoperative regimen of the patient, which should include plenty of fresh air, and sunlight, abundant nourishing food and regulated periods of rest.

FIG. 369.—Same case as Fig. 368 shows function of spine, two years after operation. The arrow indicates location of graft.

In the following table (from Albee's *Orthopedic and Reconstruction Surgery*) are presented the data on 532 inlay bone-graft operations, performed for the relief of Pott's disease on patients varying in age from twenty months to sixty-five years:

CLASSIFICATION OF 532 CASES OF POTT'S DISEASE, TREATED BY THE INLAY BONE-GRAFT OPERATION.

Location of disease.	Number of cases.	Percent.
Cervical	6	1.33
Cervicodorsal	42	9.33
Dorsal	168	37.33
Dorsolumbar	78	17.33
Lumbar	122	27.10
Lumbosacral	34	7.55

Duration of disease.	Number of cases.
Less than 1 year	58
More than 1 year	71
" 2 years	62
" 3 "	71
" 4 "	56
" 5 "	36
" 6 "	33
" 7 "	21
" 8 "	16
" 9 "	13
" 10 "	10
" 11 "	8
" 12 "	8
" 15 "	5
" 19 "	3
" 21 "	5
" 26 "	2

RESULTS OF THE BONE-GRAFT OPERATION.

Results.	Total series.		Albee's series of 198 cases (to June, 1915)[1]		292 results of 31 surgeons.		14 of the 31 surgeons		8 of the 31 surgeons.	
	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent
Disease arrested	449	84.40	184	92.9	222	76.0	..	100	..	100
Improved	59	11.00	2	1.0	59	20.0				
Unimproved	9	1.69	0	0.0						
Died	15	2.81	12	6.0	12	4.0				
Soon after operation	9	1.69	6[2]	3.0	4	2.0				
Long after operation	6	1.12	6[2]	3.0	8	2.0				
No external support used	..	..	198	100.0						

Technic of Hibbs[3] *Operation for Relief of Pott's Disease.*—"A longitudinal incision is made directly over the spinous processes through skin, supraspinous ligament and periosteum to the tips of the spinous processes. The periosteum is split over both the upper and lower borders of the transverse processes. The spinous processes are then transposed after partial fracture so that they make contact with fresh bone, the base of each with its own base and the tips with the base of the next below. The adjacent edges of the laminæ being absolutely free from periosteum, a small piece of bone is elevated from the edge

[1] Only those cases in which one year, or more, had elapsed since operation are listed.

[2] Dead. Of these, 6 were entirely relieved of Pott's disease and died of some intercurrent disorder, as follows: 1 case, aged six years, in general poor condition after five years of conservative treatment, died on the day following operation, cause unknown; The graft in this case was removed with chisel and mallet. 1 case died after four days from *acetonuria*. 1 case died from *status lymphaticus*. 1 case died from *disease of the middle-ear*, complicated by *suppurative meningitis*, two years after spinal operation. The autopsy showed a complete cure of the tuberculous lesion. 1 case died from *pneumonia*, one week after operation. The causes of death in the other cases included *amyloidosis of the viscera, tuberculosis of the lung, acute abdominal condition*. There have been only 3 of the 352 cases to die of tuberculous meningitis; and in no case was there any serious trouble with the tibia from which the graft was removed.

[3] Jour. Am. Med. Assn., August 10, 1912, No. 6, lix, 433.

of the laminæ and placed across the space between them, its free end in contact with the bare bone of the laminæ next below it. The lateral walls of the periosteum and the split supraspinous ligament are brought together over these processes by interrupted chromic catgut sutures. The skin wound is closed by silk, and a steel brace is applied with the space between the uprights increased somewhat at the site of the wound so as not to make pressure on it. In some cases the gaps in the periosteum removed from the spinous processes and laminæ have been closed by suture, thus establishing at once a continuous periosteal wall. Hibbs advises that rest in bed be absolute for eight to ten weeks; that during the next four weeks sitting up be permitted, and at the end of the twelfth week, walking. The brace is continued for another month, and then removed for a part of each day until gradually left off entirely. In the case of children under five, it is to be worn for six months."

Mechanical Treatment.—If the patient refuses operation, the only alternative is an attempt to secure immobilization by conservative measures, This is, likewise, indicated when operation must be postponed in the event of pyogenia, or infection, other than tuberculous, such as exanthemata and other complications, general infection and bacteriemia or an infected field of operation.

Mechanical treatment has as its aim the *removal* of pressure, weight and movement from the focus of infection, and the *fixation* of the diseased portion of the spine in the desired position. In tuberculosis of the spine, it should be constantly borne in mind that the disease is entirely in the vertebral bodies and its progress consists in the crushing, destruction and telescoping of this portion of the vertebra, which is caused not only by the superincumbent weight of the body above the point of the disease, but in a large degree by the constant respiratory movement and by muscle spasm.

It is, thus, evident that in any region of the spine mechanical conditions for effective splint support are unfavorable. On the other hand, it is evident that the external splint is more efficient in the lower dorsal and upper lumbar regions where a maximum of leverage above and below is possible, since the focus of disease is located in the central portion of the spine. However, in the upper dorsal region, the leverage is short and the physiological curve, together with the superimcumbent weight of shoulders and head tend to produce an antero-posterior kyphosis. In the last few lumbar vertebræ the poor leverage below the focus of disease is even more noticeable. Horizontal, recumbent fixation is the most effective form of conservative treatment in such cases.

During the stage of acute symptoms, mechanical treatment should be given in the *recumbent* posture, followed later by the ambulatory method. *Recumbent treatment* is indicated in all cases for postoperative fixation, in the instance of the patient's refusal to undergo operation, or in the case of any contra-indication to operation. It is likewise indicated in the event of acute symptoms, psoas spasm or contracture,

paralysis, abscess-formation, or lateral deviation of the spine. Greater relief of symptoms is secured by the recumbent method owing to the more complete immobilization of the spine which is possible.

Appliances for recumbent treatment are varied and numerous. Among these may be mentioned:

The Bradford-Whitman frame.
The Sayre halter and sling.
Tubby's spinal pillow.
The double Hamilton splint.
The double Thomas splint with head-piece.
Fisher's bed-frame.
Rollier's fixation straps.
Gauvain's spinal board, back-door splint and wheelbarrow splint.
The plaster bed of Hoffa and Phelps.

Only those appliances which are used by Albee in his practice will be described herewith in detail. Of these, the author considers the Bradford-Whitman gas-pipe frame to be the apparatus of choice for maintaining recumbency-fixation in Pott's disease, both in cases where operation is not indicated, and also as the postoperative fixation agent. In the cervical and upper dorsal regions and in disease of the last lumbar vertebra, this may be supplemented by certain appliances which will be mentioned in the following discussion.

The Bradford-Whitman frame is a convenient, horizontal appliance, consisting of a rectangular gas-pipe frame, one and one-half feet longer than the patient, and equal to the intra-axillary space in width. Continuing the description: "A strong canvas is stretched by means of corset-laces on its under surface. The canvas can be made in two sections with an interval between to allow for the bed-pan. Two felt pads about seven inches long and three-quarters of an inch thick are

FIG. 370.—Whitman frame, with head traction. This patient is making a good recovery from tuberculosis of the spine, hip and wrist tendons.

sewed to the canvas to relieve the tip of the kyphosis from pressure, and thus prevent excoriation. The patient is held in place by a front-piece, or apron, secured to the sides of the frame by straps and buckles. As soon as he becomes accustomed to the restraint, the hyperextension of the spine is increased from time to time by bending the frame upward

beneath the kyphos. This tends to separate the vertebral bodies, relieving them partially for the time being from friction and pressure.

"The patient is kept constantly upon this frame, the clothing, in the cases of children, being made large enough to include the apparatus, thus assuring better fixation and avoiding the removal of the child from the frame for the purpose of changing the external clothing. The patient should be removed once a day, inspected, bathed with alcohol, and powdered with talcum, or stearate of zinc, etc., after which the apparatus is reapplied. Great care must always be taken in handling the patient, who should never be allowed to assume the vertical position."

The Sayre halter and sling is used to secure traction in disease of the cervical region and in acute stages of dorsal disease above the ninth dorsal vertebra. Whether the child is on the frame, or in a spinal brace, or a plaster-of-Paris jacket, greater fixation may be obtained by use of this halter which is fastened to a cross-bar at the upper end of the frame. Traction may be exerted on the limbs by weights attached to the legs by means of adhesive strapping and ropes running over pulleys fixed at the lower end of the bed in disease of the last lumbar vertebra.

In the conservative treatment of all acute cases, immobilization of the patient on the horizontal frame is the primary essential. Although not an absolute fixation, this is the most efficient of any of the conservative methods. Recumbent fixation is not an ideal method of treatment, for ambulatory fixation by brace or plaster-of-Paris jacket ultimately becomes necessary. Duration of the frame treatment may range from six months to three years. Indications for its discontinuance are relief of all symptoms and evident arrest of the local disease, and the increased freedom of movement and restlessness of the patient upon being taken from the frame for sponging, etc. Further indications for a termination of the horizontal fixation include disappearance of pain, an increase in body-weight, absence of the deformity (or stationary) and continued absence of evening rise of temperature for several months. An *x*-ray examination should be made.

The *ambulatory supports* most commonly employed are the *steel brace* and the *plaster-of-Paris jacket*, supplemented by some type of head-support when the disease is located above the ninth dorsal vertebra. Choice of these modes of support depends upon the age of the patient and the intelligence and coöperation of the patient's family. A spinal support, to be serviceable, should fulfill the following requirements: There should be "a fixed point from which pressure may be exerted, preferably the pelvis. Pressure should be carried along the transverse processes of each side, especially in region of the kyphosis. There should be no compression of the lateral chest-walls, but compensatory pressure on the upper portion of the anterior chest wall and the pubic and pelvic regions. If the disease is located between the eighth and tenth dorsal vertebræ, the support must extend above and in front of the shoulders. If above the eighth dorsal vertebra, the support must include the head and neck."

The Plaster-of-Paris Jacket.—"All that can be expected of the brace or the plaster jacket is to hold the spine in general alignment. It is a simple splint to the whole spine, and only partially fixes the individual segments. Its efficiency depends upon the accurate and smooth application over the body's irregularities and upon its leverage above and below the diseased focus. It should be applied with the spine held in the most favorable hyperextended position which, as a rule, is obtained by the Sayre or Calôt suspension apparatus (see Figs. 371 and 372), or by Roberts' extension jack appliance.

"After the skin is prepared by bathing with alcohol and dusting with talcum powder, a seamless jersey shirt or stockinette is applied. This should be made of sufficient length to allow of its being turned up to form an outer cover to the jacket. The patient is then placed upon a stool and the halter of a Sayre or Calôt suspension apparatus is adjusted about the head. The arms are extended above the head and grasp the suspending straps on each side. The patient is then suspended by sufficient traction to raise the heels off the stool. The antero-superior spines and the crests of the ilia and the sternum are protected by piano felting. The spinous processes of the kyphosis are protected by a strip of saddler's felt placed on either side to protect them from chafing and to allow the application of greater pressure and fixation at the point of disease. In adolescent and adult females, the breasts are protected by cotton, which may be removed later if there is undue pressure. No 'dinner pad' is used, except in thin adults.

"The bandages are wound smoothly about the patient, and while the jacket is being applied, an assistant sits in front holding the patient's thighs to prevent swaying and rotation. A second assistant, standing to the side, rubs each layer of plaster bandage thoroughly as the turns are made by the surgeon, who stands at the back of the patient and also rubs each layer thoroughly. Care should be taken that the jacket is made of uniform thickness throughout, $\frac{3}{16}$ to $\frac{1}{4}$ inch. It should extend above the sternal notch and below the anterior superior iliac spines sufficiently to afford plenty of length for trimming. Before the plaster sets, it is molded so as to increase its leverage, and trimmed. It should be left as long as possible and allow flexion of the thighs and motion of the shoulders.

"The patient should be placed in a recumbent position for not less than one hour after the application of the jacket, in order to insure sufficient hardening and firmness before strain is brought to bear upon it by the patient's assuming an erect posture. If the disease is above the ninth dorsal vertebra, a jury-mast or head support incorporated in the plaster is necessary to lengthen the leverage above the point of disease and aid in holding the upper portion of the spine in hyperextension."

Various modifications of the plaster jacket are made in individual cases: the head is sometimes included in the plaster, in place of a jury-mast; or the plaster is molded up over the shoulders in order to obtain sufficient hyperextension. In cases of psoas spasm, or acute disease

lower down, one or both thighs may be included in the plaster. Gauvain recommends and uses two varieties of plaster jacket: the "fillet," so-called from the narrow strip, or fillet, of plaster which is wound about the head in such manner that the head is kept extended; and the "Minerva," which reaches high enough to be just below the jaw, mastoid and occiput. In some cases the *hammock frame method* is

FIG. 371.—The Calôt military plaster-of-Paris jacket for immobilizing the lower dorsal and lumbar spine.

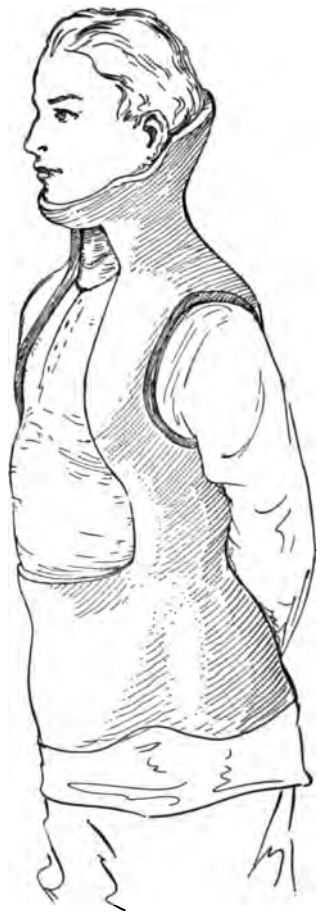

FIG. 372.—The Calôt "grand" plaster-of-Paris jacket for immobilizing upper dorsal and cervical spine.

employed, in which the patient lies prone on a strip of cloth during the application of the jacket. The greater comfort of the patient, the avoidance of tendency to syncope and the possible hyperextension are advantages of this method.

"A very efficient method is that of the *modified Calôt*, where a corrective-jacket is worn in recumbency for from one to two years, followed

by the *military* style for all cases below the ninth dorsal vertebra, and the so-called *grand* style for all cases above that level. In the hands of the author, it has been found preferable to use the American plaster-of-Paris roll in applying this jacket instead of the technic of cream plaster and pattern crinoline method of application advised by Calôt, and so dextrously used by him. In applying the military and grand

FIG. 373.—Plaster jacket with jury-mast, just applied. Note the tilting back of head. The stockinette hanging down will be turned up over the jacket and sewed to itself at the top. (Taylor.)

types of the Calôt, the Sayre suspension apparatus is used, excepting the leather halter. As a substitute, portions of three-inch muslin bandages have been adjusted about the chin and occiput, and held in place by means of large safety pins, so as to be easily removed. The military jacket is applied in a way very similar to the ordinary jacket, except that the shoulders are padded and included in the plaster with

a military collar above. The 'grand' differs in that the head is hyperextended and held by including the chin and occiput.

"In the case of either type of jacket, a square window is made over the kyphos, sufficiently large to admit a layer of thick felt with a hole in the center to allow periodical increase of pressure on the spinous processes of the kyphos. This is placed in contact with the stockinette, and the corrective force is established by forcing in layers of cotton, after which the square of plaster removed is fastened in place again, under pressure, by a few layers of plaster-of-Paris bandage. A large

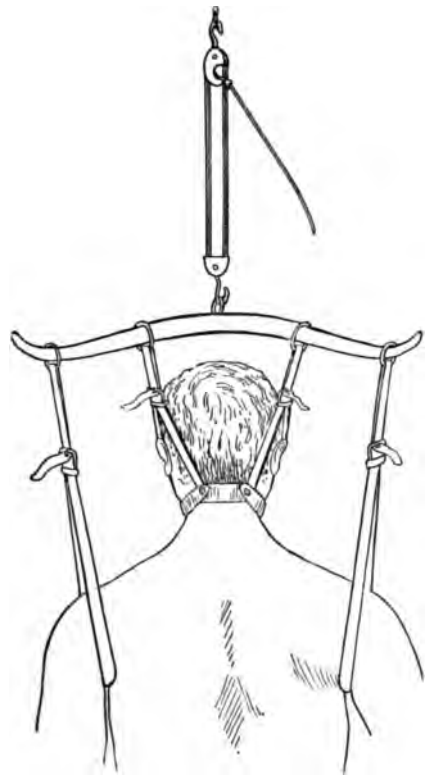

FIG. 374.—Sayre head-piece for suspension in Pott's disease. (Bradford and Lovett.)

triangular window with its apex upward is made in front of the jacket in such a position as to allow the thorax and spine to be forced upward at the level of the kyphosis. A constant corrective pressure is maintained by removing the posterior plaster window and adding to the cotton padding at intervals of two weeks, as the hypothesis recedes."

The methods of *Brackett, Lovett* and *Goldthwait* have all been developed on the foregoing principles.

Among the *spinal braces* (the second type of spinal support) may be mentioned Knight's spinal brace, Schapp's brace, Tubby's spinal sup-

port, Thornton's back brace, Davies' quadrilateral brace and various leather and celluloid jackets. The spinal brace recommended and used by the author is the steel brace of Dr. C. F. Taylor, widely employed ever since its introduction by Taylor, in 1863. The brace is described, as follows:

"This consists of two parallel steel uprights, ½ inch wide, gauge 8 to 12, one on each side of the spinous processes, extending from the

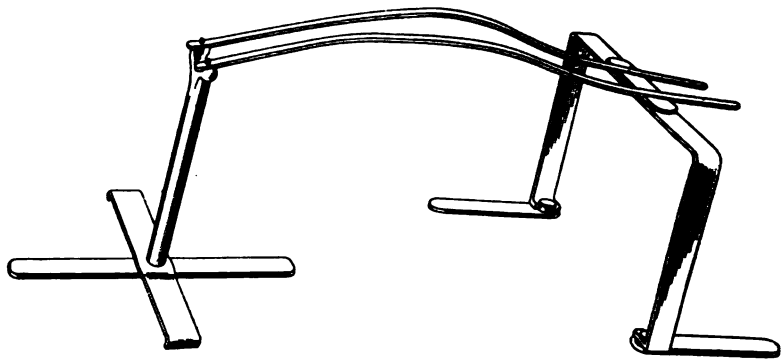

FIG. 375.—Goldthwait's portable frame for applying the plaster jacket. (Whitman.)

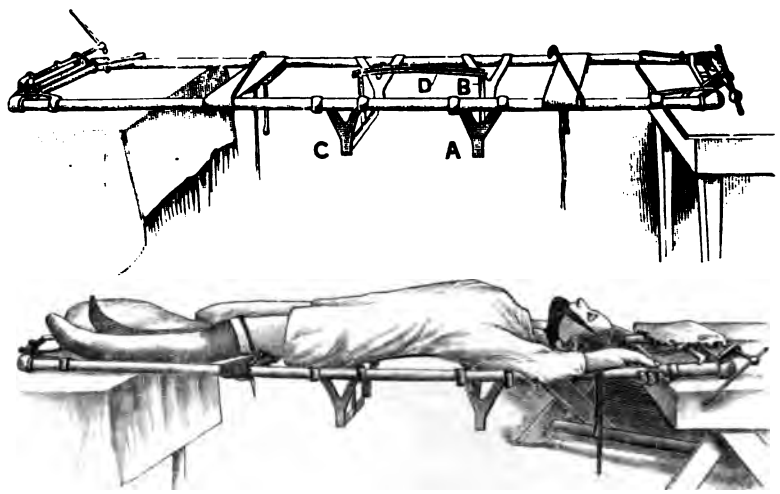

FIG. 376.—The plaster jacket applied in supine posture by means of the Metzger-Goldthwait apparatus. (Whitman.)

buttocks to the seventh cervical vertebra. Pressure pads of ground cork, or soft leather, are adjusted on the under surface of the uprights: These allow greater pressure for fixation and correction of deformity at what is the fulcrum of the brace lever when the upper and lower ends are fixed to the shoulders and pelvis. To the lower ends of these uprights is fastened a pelvic band of short steel, 1½ to 2 inches wide, with average gauge 18, and reaching from one iliac spine

to the other. Opposite to the second dorsal vertebra, two shoulder pieces of lighter metal extend over the shoulders to about the middle of the clavicle. These are padded, and from their ends padded shoulder straps are continued around and under the arms, and then buckled to the uprights at about the level of the angle of the scapula. Additional fixation is had by applying an apron covering the abdomen and fastened below by a strap sewed at its lower border to buckles at the end of the pelvic band. The upper border is similarly arranged with straps and buckles to uprights at a level with the axilla.

FIG. 377.—The jury-mast. (Taylor.)

"To measure for the brace, have the child face down on a firm flat surface. A lead tape is then applied along the spine over the lateral masses and an exact outline is then transferred to a piece of cardboard and trimmed with scissors for use as a pattern in shaping the uprights. Modifications and changes can be made to adapt this brace to special indications, but that shown in the accompanying illustration is the one used in the average case. In cases where the disease is above the ninth dorsal vertebra, a hard rubber chin cup or jury-mast attachment to the brace is necessary.

"It should be appreciated that the correction obtained by plaster

jackets, steel braces or other external appliances is most difficult to maintain owing to an irreparable loss of substance in the diseased vertebral bodies and also because there is so little osteogenesis. Mechanical support can never be removed without great apprehension of a relapse of the deformity or of the disease, and should be discarded with the greatest conservation. It is in this particular, among others, that operative treatment is so much to be preferred in that bone support is quickly and directly applied, the simplicity of the operation being indicated by the short time in which it can be performed."

Head supports are required when the disease is above the ninth dorsal vertebra. A jury-mast or some other type of head support is incorporated in the plaster in order to lengthen the leverage above the point of disease, as well as serving as an aid in holding the spica in hyperextension. The jury-mast is most frequently used with the plaster jacket in cervical and high dorsal disease. Made of tempered steel, this support has a base consisting of a flat steel bar about 3 x 1½ inches. "From the extremities of this bar, flat steel bars curve down-

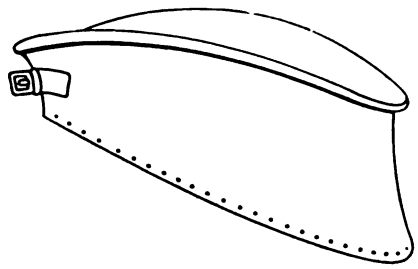

FIG. 378.—The Thomas collar for permanent use. A piece of thin sheet metal is cut wide enough to reach from the sternum to the chin, and from the back of the neck to the base of the occiput. The edges are turned out and the whole properly covered with felt and fitted. (Ridlon and Jones.)

ward and outward, and to the extremities of these are fastened lateral plates of perforated tin. The base piece is incorporated in the plaster jacket, the transverse bar crossing opposite the second dorsal vertebra and the lateral pieces passing over the scapula of each side. The mast proper passes from the center of the base-bar upward to below the occiput where it curves backward, conforming with the outline of the skull, but about one and one-half inches distant from it. It ends over the center of the vertex, but about two inches above it. To its extremity is rivetted a narrow steel cross-bar, extending laterally the length of the biparietal diameter. A halter is slung from the two ends of this cross-bar and by leather bands is attached to a chin piece in which the occiput and chin are supported. As much tension as can be borne should be applied. The chin should be tilted upward to get hyperextension; this is best accomplished by shortening the halter strap passing to the chin."

Other types of head supports include the *Taylor ring, Davies head support, Thomas collar and Goldthwait's head support.*

Correction of the deformity may be classified, as *operative correction* and *gradual correction*. In correction by operation, the various procedures, in order of choice are:

1. Albee's method of bone-graft correction and fixation.
2. Calôt's method of correction under anesthesia.
3. Removal of the spinous processes.

Correction and fixation by Albee's bone-graft operation (see foregoing description of technic, p. 908) is designated to *cure* the disease. Incidentally, it also affords correction of the deformity. "If the spine is markedly kyphotic and angular, and the disease of short duration in a young subject, fixation of the patient on a Bradford-Whitman frame for some time prior to operation will oftentimes largely correct the kyphosis before operation and enable the bone-graft to maintain the correction. With care, much correction can be accomplished at the operation by manual force and by using the graft as a lever as it is inserted under the dense ligaments."

Calôt's Method of Rapid Correction Under Anesthesia.—"The patient is anesthetized and suspended face downward, in the horizontal position by five assistants who exert traction upon each of the extremities and upon the head, while the surgeon gently presses directly downward upon the kyphosis. The deformity gradually yields and is overcome. The amount of pressure necessary varies from 30 to 60 pounds. The correction thus secured is maintained by applying a plaster jacket with the spine hyperextended; recumbency is required for three to six months, and a spinal support is necessary for at least a year thereafter.

"This method has proved disastrous in a very large percentage of cases, not only in Calôt's experience, but in that of all others, because Nature's efforts at fixation are largely destroyed, *i. e.*, the fixative influence of connective tissue and bone proliferation are broken up and destroyed, and the surgeon has been unable by his conservative appliances to immobilize the spine sufficiently to prevent relapse of the disease. . . . The insertion of the graft enables the surgeon not only to maintain the correction of the deformity but to accomplish immediate fixation. The operative correction of a kyphosis, however, should be attempted with the greatest caution and care exercised in the selection of cases."

Any method of securing fixation by means of metallic agents, such as the wiring of the spinous processes (advocated by Hadra in 1891) or Lange's internal steel splints are highly condemned on account of the destructive influence upon the bone exerted by contact of such foreign substances.

Gradual Correction.—A useful preliminary method to fixation by bone-graft is the Bradford-Whitman brace, described above. *Goldthwait's horizontal traction* and *leverage method, Calôt's plaster jacket* and the *extension couch* and *weight traction* are forms of gradual correction which should be mentioned. The following description of Calôt's plaster jacket is given:

"After an ordinary plaster jacket has been applied, a small window is cut posteriorly over the deformity and a large window in front. Several pieces of wadding are cut, each slightly larger in size than the posterior window, and about 1 cm. thick. They are introduced through the window between the jacket and over the deformity. Eight or ten layers of wadding are sufficient for the first compression. These compresses bulge out through the window and further compression may be obtained by replacing the cut-out piece of plaster over them and forcing it inward by a few turns of plaster bandage or adhesive straps. As the kyphosis diminishes, more compression pads are added until 15 to 18 are introduced at the third or fourth insertion."

Complications and their Treatment.—The principal complications encountered in Pott's disease are *paralysis* and *ichor-pocket formation* (cold abscesses).

1. *Paralysis* is a symptom, and as such its primary treatment is the treatment of the condition causing it. *Absolute fixation* of the spine in its affected portion is the aim, and the bone-graft fixation operation, already described in this section, is the procedure of choice. When the deformity is remediable, cases should be given treatment by hyperextension on the Bradford-Whitman frame, preliminary to the operation. Trophic disturbances, such as bed-sores, should be guarded against by extreme care of the skin. Deformities from muscular contractures are treated by weight extension. In bone-graft fixation before any permanent structural alterations have become advanced in the spinal cord, the rate of recovery from paralysis is very high.

Other operative procedures aiming at the relief of paralysis, such as laminectomy and costotransverse excision, are rarely indicated.

2. *Ichor Pockets.*—"The word *abscess* is a misnomer when applied to the primary circumscribed collection of tuberculous detritus formed from the disintegration of bone and soft tissue plus granulation exudate. The term *ichor pocket* is more suitable, accurate and graphic. When secondary infection of this ichorous material has occurred, then the word abscess, a circumscribed collection of pus, is eminently appropriate." An ichor pocket should, as a rule, be let alone. The sterile, semifluid detritus is innocuous, generally causing no discomfort and once the bone lesion in which it originated has been cured, it disappears.

Operative interference, when necessary, consists of *aspiration*, or *incision*. This is indicated in the case of any *mechanical interference with function* (as with the application of brace or splint); *discomfort from tension; evidence of pressure necrosis;* or of *secondary infection*.

Aspiration is far preferable to incision, when operative interference with an ichor pocket is warranted. Selecting a thick portion of the wall, the needle is carefully introduced at an oblique angle. No disturbance of the granulations lining the wall should be made because we are concerned with a large cavity which may fill with blood clot which would offer a far more favorable culture medium for bacteria than the tuberculous ichor. Following aspiration, the patient should be given recumbent treatment, thereby permitting a return of the remaining ichorous material to its point of origin.

Incision is indicated *only* when it is necessary to remove fibrous clots which could not be removed by aspiration.

The following *general rules for both aspiration and incision* are taken from Albee's *Orthopedic and Reconstruction Surgery:*

1. Recumbency and gravitation prior to operation.
2. Rigid asepsis.
3. In evacuating a large ichor pocket pointing in two locations, as loin and hip, in Pott's disease, to avoid disintegration of the line of suture from force of gravitation, it is preferable to aspirate or incise the one on a higher plane, with the patient standing, rather than the dependent one.
4. Select the thicker portion of the wall.
5. Avoid injuring the granulation lining the cavity, as this minimizes the chances of a postoperative hematoma; hence, express the contents carefully.
6. The incision should be long enough to allow fibrous clots to be expressed.
7. No instrument should be introduced into the ichor cavity.
8. Suture the incision carefully in layers, using absorbable material.
9. Dressings should be large and should exert firm, even compression, so as to prevent the ichor pocket from refilling with exudate or blood-clot.
10. Recumbent position for two weeks, or more, after operation to prevent breaking down of the wound by gravitation.
11. Heliotherapy after operation.

There are vertebral ichor pockets pointing in localities which require special treatment, such as the *retropharyngeal,* or *prevertebral cervical* ichor pocket; the *supraclavicular* ichor pocket; the *prevertebral thoracic* ichor pocket; the *iliac* ichor pocket and the *lumbar* ichor pocket, including the *ichor pocket in Petit's triangle* and the *subcostal* ichor pocket.

In the case of the *retropharyngeal,* or *prevertebral ichor pocket,* incision should never be made through the mouth, owing to the great danger of secondary infection. "The incision follows the upper third of the posterior border of the sternomastoid muscle. Avoid the spinal accessory nerve emerging from the posterior border of the muscle. Retract the muscle forward, securing freer exposure, if necessary, by partially severing it near the mastoid. The splenius and levator anguli muscles are now exposed. The ichor pocket lies in front of the transverse processes; access to it is obtained by the finger passed inward along their exterior surfaces displacing forward the anterior jugular vein which lies in front of the abscess. If the ichor pocket extends across the neck to the opposite side, a second opening should be made behind the opposite sternomastoid. The cases should be watched carefully as edema of the glottis occasionally occurs."

When dyspnea and dysphagia are urgent symptoms, an incision through the mouth may be made. The head hangs well over the edge of the table, in order to prevent inspiration of the pus, and the jaws

are kept apart by means of a mouth-gag. After the ichor pocket has been opened, the patient is turned quickly upon the face and kept in this position until evacuation of the pocket is completed. It is advisable to use an antiseptic mouth wash until the wound has healed.

Supraclavicular Ichor Pocket.—"In disease of the middle cervical vertebra, tuberculous ichor passes between the trapezius and sternomastoid muscles and points in the posterior triangle of the neck above the clavicle. Incision should correspond with the lower two-thirds of the posterior border of the sternomastoid muscles, care being taken to avoid the spinal accessory nerve. Retract the sternomastoid inward, until the outer edge of the scalenus anticus is in view. Enlarge the interval between the scalenus and longus colli muscles with the fingers, forceps, or scissors to evacuate the ichor pocket."

Prevertebral Thoracic Ichor Pocket.—"A collection of tuberculous ichor in this locality, between the mediastinal pleura and the vertebral bodies, usually presents no objective signs or subjective symptoms. Occasionally pressure symptoms on esophagus, trachea, left recurrent laryngeal nerve, or spinal cord demands operative intervention. Relief is obtained by one of two procedures: *rib resection*, or *costotransverse excision*.

Rib Resection.—"With the patient in a semiprone position, healthy side downward, make an incision parallel with the spinous processes of the affected vertebræ, about one and a half inches from the middle line, exposing the articulation of rib and transverse process. Divide and elevate the periosteum over the posterior surfaces of one or two ribs, and divide and remove one or two inches of the latter. Incise the exterior costal periosteum, pass the finger inward and forward along the anterior surface of the transverse processes and in front of the vertebral body, and open the ichor pocket. The disadvantages of the operation are the inaccessibility of the lesion, the imperfect drainage attainable and the danger of injuring the pleura."

Costotransversectomy (Costotransverse Excision).—"A straight vertical incision is made close to the spine and the soft tissues separated outward as far as the tubercle of the rib. First resect the transverse process of the affected vertebra, then the head and neck of the rib. Introduce the finger, strip the pleura from the side of the vertebra and penetrate the ichor pocket."

Lumbar Ichor Pockets.—"Ichor pockets from tuberculous lumbar vertebræ appear in the loin and usually point in one of two common localities: (*a*) between the erector spinæ muscles and the last rib, or (*b*) above the iliac crest, in Petit's triangle." . . . For an ichor pocket in the *subcostal region*, "make the incision along the lower border of the last rib, from the outer edge of the erector spinæ. Divide the latissimus dorsi and serratus posticus inferior and the outer fibers of the quadratus lumborum and the middle layers of the lumbar fascia. After evacuation, close the wound at once." . . . In the case of an *ichor pocket in Petit's triangle*, "make an oblique incision passing downward and outward, exposing Petit's triangle. The ichor pocket

usually lies in front and to the outer side of the transverse processes of the fourth and fifth lumbar vertebræ."

Iliac Ichor Pockets.—"Make the incision parallel with and about one inch above Poupart's ligament and of a length commensurate with the size of the ichor pocket. Split the fibers of the external oblique, internal oblique and the transversalis muscles. Dissect close to the anterior-superior iliac spine, exposing the transversalis fascia, but exposing the ichor pocket behind the latter. If the pocket is prolonged downward into the thigh it may be necessary to make a second incision just below the anterior superior iliac spine and along the outer border of the sartorius, which is retracted and the pocket entered through the fascia over the iliopsoas internal to the tendon of the rectus femoris. The point of election, however, should be the less dependent location near the anterior-superior iliac spine. All incisions should be carefully closed."

NON-TUBERCULOUS AFFECTIONS OF THE SPINE.

Rickets (*Rachitis*).—This is a constitutional affection in children, occurring usually during the first dentition. Owing to lack of hygiene and poor dietetic conditions the normal process of ossification is disturbed, resulting in enlargements of the epiphysis, with a delayed and a defective growth. The bones become soft and pliable and the deformity is due to hypertrophy and pressure or weight-bearing.

"The spinal condition is always associated with other evidences of rickets elsewhere and is characterized by absence of rigidity and by disappearance of the deformity when the child is laid prone and supported by thigh and chest. It is usually a part of a general attitude in which the body is inclined forward and the spine bent in a slightly rigid posterior curve, which is most marked at the junction of the dorsal and lumbar vertebræ. This condition of the spine is easy to diagnose, as it is usually associated with enlargements about the wrists, ankles and at the junction of the ribs and the costal cartilages, together with delayed dentition, slow-closing fontanelles, pigeon-breast, pot-belly and a failure to walk at the usual age."

Treatment.—The treatment of rickets should be hygienic, dietetic and medicinal. In the advanced cases a simple spinal brace or recumbency during a short period of time upon the Bradford frame may be necessary, although, in most cases of rickets, support of the spine is not essential. These cases offer a very favorable outlook for recovery under the proper care and treatment. Only in those cases which are observed too late in the progress of the disease is permanent deformity liable to occur.

Scorbutic Spondylitis.—Scorbutic spondylitis, or *Scurvy*, is one of the group of dietary deficiency diseases, and is dependent upon the resultant impaired nutrition. Owing to its frequent occurrence in conjunction with rickets, the two conditions may be confused. It is rarely encountered in the spine, being more frequently seen in one of the long bones,

FIG. 379.—Rachitic spine in a child one year old. (Taylor.)

FIG. 380.—Same case as preceding figure, showing disappearance of kyphos in prone posture. (Taylor.)

as, for example, the femur. When it does occur, it usually affects bottle-fed babies from six to eighteen months of age. The first symptoms are pains in the joints of arms or legs, and distress when the spine is moved. When the latter is affected, it is very tender, though it gives no evidence of swelling, nor of redness. Examination of the mucous membrane and skin, or of the gums, following dentition, will give evidence of small and repeated hemorrhages. Blood effusion may occur about the joints.

Treatment.—Treatment of scurvy should be primarily *dietetic*, consisting in a substitution of fresh modified cows' milk for artificially prepared milks, or patent foods, which are an important factor in the etiology of the disease. The spine must be kept undisturbed on the Bradford frame, or the Phelps cuirasse, during the period of pain.

FIG. 381.—Rachitic curvature of the spine.

Syphilitic Spondylitis.—Syphilitic spondylitis is frequent in children, but rarely occurs in adults. The commonest location is in the cervical region, due to its proximity to the pharynx. All regions are susceptible, including every part of the vertebræ, the bodies, ligaments, intervertebral disks, transverse and articular processes and the muscles. Although similar in all respects to syphilis of other joints, it may be difficult to diagnose syphilitic spondylitis on account of its frequent association with tuberculosis. A periostitis and a hyperplasia may occur as a result of the disease rather than a degeneration. Frequently there is distressing pain from movement and from compression about the nerves. There may be abscess-formation, although such is not the rule. The deformity may be similar to that in Pott's disease and must be differentiated. In children under three years of age, spondylitis associated with some other chronic joint lesion is usually syphilitic in nature; cutaneous eruptions, nasal catarrh, Hutchinsonian teeth, a

history of syphilis in the parents, and the like serve further to differentiate the two disorders. The roentgenographic and Wassermann findings should be final.

Syphilitic aneurysms of the aorta may invade the adjacent vertebræ. The vertebral bodies become thickened with extensive osteophytic development, and ankylosis and ossification of the ligaments may take place. Fracture of the involved bones is common.

Treatment.—The treatment of syphilitic spondylitis should be both mechanical and medicinal and should extend over a period of a year, or more. Rest is essential. Spinal support in the acute stages is necessary and supplemental treatment by salvarsan and neosalvarsan. Mercury and iodides should be carried persistently. Owing to adverse mechanical conditions, symptoms frequently persist, and in such cases, the bone-graft, as applied by Albee for the relief of Pott's disease, should be employed.

Spondylitis Deformans, or Arthritis Deformans of the Spine.—It is the custom today to consider all cases of chronic rigidity of the spine, of unknown origin, as arthritis deformans. The term, thus, includes a large number of chronic conditions in and about the joints, among these, chronic rheumatism, rheumatic gout, osteo-arthritis, chronic ankylosing spondylitis, the arthritis deformans of Virchow and the rheumatoid arthritis of Garrod. Spinal involvement may be associated with disturbances in other joints, or it may exist independently.

Frequently the cause of the arthritis is unknown; it may be secondary to some local septic process elsewhere in the body, as is often found about the base of the tonsils, or at the roots of the teeth. It may be secondary to prostatic, intestinal or skin disturbances. The organism may be present in the joint, or, as a result of its metabolism, produces the toxic changes in or about it.

Arthritis deformans is about equally divided between men and women, but spondylitis deformans is far more frequent in males. It is only occasionally seen in negroes. Most cases occur in middle life, but cases are seen occasionally in children, and ankylosis occurs sometimes during adolescence and in the aged. "The disease is insidious and usually progressively chronic. The chief complaint is pain, which is due to nerve involvement or muscle spasm. It is usually a referred pain, hence it may be thoracic, abdominal, sciatic or neuralgic. New bone formation interferes with motion, and there is gradually more or less rigidity, as a result. The deformity depends largely on the nature and the extent of the changes about the vertebræ. Hence, in these cases in which the cartilages are destroyed without bony replacement, we get the straight, stiff 'pole-back.' Then, again, a marked bowing and ankylosis may result. Distortion occurs from the ossified ligaments. The deformity and pain may interfere with the nervous system to such an extent as to undermine the health. The patients may look weak, worn and haggard, with body bowed forward and head projecting and with eyes staring. Muscular wasting is frequent both in the back and in the legs. Disturbances of sensation are common, and the *x*-ray

may show deposits of bone which are characterized by their extreme irregularity and which may be largely on one side, or in the ligaments."

Symptoms.—The clinical features in the cases of general involvement are so characteristic that little need be said regarding their diagnosis. It is only in those cases of stiffness, interference with motion, indefinite pains, the so-called lumbago and weakness, that differentiation is difficult. Examination of the spine may show nothing but tenderness and slight limitation of motion. Or we may notice the beginning of muscular wasting. Tuberculin may help to clear the diagnosis, if used in conjunction with the *x*-ray examination.

FIG. 382.—Spondylitis deformans in a man aged forty-eight years. The hips and the knees were also affected by arthritis deformans.

Treatment.—The treatment in the early and acute cases is essentially one of rest. The results from the spinal support, such as plaster jackets and Taylor's braces, are gratifying. Otherwise, symptomatic treatment is best. The removal of etiological septic foci is important. Vaccines prepared from such foci are being tried with some success. In the event of failure to demonstrate a pyogenic focus, and hence, to obtain an autogenous vaccine, a complement-fixation test may be made and a corresponding stock vaccine employed. Thus, cultures taken from enucleated tonsils and from pus at the base of the teeth are being used. Radium has been tried with little success, given by

rays, and also by injecting it intravenously. Salicylates given in large doses, with twice the amount of bicarbonate of soda, seem to help many cases. In very rare cases, the process may be limited to so few vertebræ, that the implantation of a bone-graft may control the condition. The *prognosis* is not very hopeful, as regards the correction of the deformity, or delaying the symptoms. As far as life is concerned, the outlook is good. Excluding the cases of nervous wreck, the limit of life is apparently not influenced to any great degree in the majority of cases.

FIG. 383.—A case of infectious ostitis of the lumbar spine. The arrows indicate the large amount of new bone formation which is in such marked contrast to the absence of bone proliferation in tuberculosis of the spine. Ultimate telescoping of the vertebral bodies can be prevented in such cases by conservative splint treatment because of the active bone proliferation.

Acute Osteomyelitis.—Acute osteomyelitis of the spine is very rare; nevertheless it has been extensively considered in the literature. Cases of perivertebral abscesses have been mentioned by English, French and German writers, as far back as 1833. The condition is similar to acute

osteomyelitis found elsewhere in the body, ranging in its occurrence from a periosteitis and superficial osteitis of mild degree to a virulent and multiple osteomyelitis. It is more frequently encountered in the mobile portion of the spine, namely, the lumbar region. According to Frohner's statistics, in 1889, only 1 case was seen in the spine out of 545 such cases in bones of the body. An increasing number of cases in the spine are, however, being observed, and it is found twice as often in males as in females. The majority of cases occur in young adults.

This condition is caused by injury to the spine, fatigue, exposure and the presence of some local septic process. The symptoms vary in accordance with the degree of involvement; in cases in which there is only periosteal involvement, local tenderness, slight pain and fever with a little stiffness, may be the only symptoms noted; a large abscess is not infrequent in the severe cases. The condition begins with chills, high fever, vomiting and the signs of a severe acute infection; pain in the spine and local tenderness follow. Suddenness of onset, acute symptoms and extreme tenderness are characteristic of this condition. In the severe cases an abscess forms rapidly; it rarely breaks through the dura, but often causes an accumulation of pus in the loose areolar tissues about the spine. Pressure symptoms of the cord are frequently caused by edema, the patient rapidly showing signs of a general pyemia. Deformity is rare on account of the gravity of the disease. The mortality exceeds 50 per cent., and the condition is strictly a surgical one. The *x*-ray is of value in diagnosis.

Treatment.—The immediate evacuation of the abscess must be made and the thorough opening of all pus-pockets in the vertebræ, with the establishment of good drainage. In cases of involvement of the body of the dorsal vertebræ, Ménard's costotransversectomy is the most successful method of getting at the pus.

Typhoid Spine.—Typhoid spine was first noted by Gibney in 1889. Only about 70 cases have been recorded in literature; in a few instances the typhoid bacillus has been isolated in the pus. No age appears to be immune and the male sex is more frequently attacked than the female. An important etiologic factor is *trauma*. More than one-half of these cases arise during the period of convalescence, and all of the cases occur within a few months, 90 per cent. within the first month, of the disease. The most common location is in the lumbar region. *Pain* is constant, especially when the spine is moved; frequently there are also referred pains. Redness, tenderness and local swelling may occur, as well as spinal rigidity and kyphosis. Cord symptoms may range from those of an irritative nature to a complete paralysis. The *Widal reaction* is usually positive in these cases. The lesion is generally a spondylitis, or a perispondylitis; however, ostitis, periostitis, chondritis, or osteomyelitis may occur. In typhoid spondylitis, the series of changes occurring resemble those in arthritis deformans.

Prognosis and Treatment.—The outlook is good in these cases. Recumbency, immobilization by means of spinal brace, plaster jacket, or, rarely, by bone-graft (as for Pott's disease) should be employed, together with massage and the cautery. The prognosis is favorable both with respect to deformity and recovery.

Gonorrheal Spine.—Gonorrheal spine is more rare than the typhoid spine, although gonorrheal involvement of the joints occurs frequently. Diagnosis is made certain in such cases if, in addition to a positive gonorrheal fixation test, the stiffness and pain follow a frequent and chronic urethritis, involving other joints, as well. Bradford reports a case of gradual ankylosis, extending from sacrum to occiput.

Treatment.—Treatment of this condition consists primarily in eradication of the focus of infection. Rest and support of the spine are essential, as well as hot and cold local applications. Following subsidence of acute symptoms, the spine should be immobilized, in accordance to the degree of pathology, preferably by means of a plaster jacket. Subsequently, partial immobilization by a removable splint and the application of passive exercises are recommended.

Osteomalacia.—Osteomalacia is a disease of the bones, characterized by absorption and disappearance of the lime salts. It is an affection of adults, principally of females; in the latter cases it is incident to pregnancy and continued lactation. Not only does absorption of lime salts of the bones take place, but congestion of marrow with increase of fatty and lymphoid substances. The cortex becomes a thin shell of bone which bends, or breaks, *spontaneous fractures* being common in such cases.

Symptoms.—Symptoms include constant pain in pelvis and spine, intensified upon exertion. There is a typical *waddling gait* in walking. Muscular weakness is evident; muscular tremors and ankle-clonus are present; the knee-jerks are emphasized. The deformity is first noticed in the pelvis which shows an extreme lateral flattening, resulting in a sharp anterior projection. The long bones become bent, or they suffer spontaneous fracture. The ribs are compressed laterally. The spine becomes scoliotic, or kyphotic.

Treatment and Prognosis.—The prognosis is very unfavorable. Hygienic surroundings, cod-liver oil, bone-marrow, phosphorus, and the like, have been used with varying degrees of success. Double oöphorectomy in non-child-bearing women has occasionally been known to halt the disease.

Actinomycosis and Blastomycosis.—Cases of actinomycosis, or ray fungus, with involvement of the spine, are exceedingly rare, and are practically all secondary and of minor importance to the primary growth. A case of blastomycosis of the spine was reported in 1908 by Brewer. Discovery of the growth by microscopic examination of granulation tissue or pus taken from the abscess establishes the diagnosis in each of these conditions.

Acromegaly.—Acromegaly is characterized by kyphosis (usually in the cervical region), enlarged head and thickened long bones. The

bony lesions are symmetrical, accompanied by hypertrophic bony changes in the face, giving it a characteristic leonine appearance Occasional temporary retardation of the disease has been possible by administration of the extract of the pituitary body. The disease is, however, progressive, and no definitive treatment is yet known.

FIG. 384.—A case of acromegaly.

FIG. 385.—Same case as the preceding figure.

Paget's Disease.—Paget's disease, or osteitis deformans, first described in 1876 by Sir James Paget, is very rare. The spine is only a part of the general bony involvement. Sometimes, the skull may be one-half to three-fourths of an inch in thickness. The bones, particularly clavicles, ribs, pelvis, femora and tibiæ, are symmetrically affected, their shafts becoming white, massive and nodular. There is noticeable kyphosis of the spine and frequently partial ankylosis. The condition is undoubtedly an inflammation of unknown nature, but its relation to syphilis is suspected. It is an insidious disease which begins late in life and is progressive. *Early symptoms* are weakness and rheumatic pains in the legs which show a gradual tendency to grow shorter. Coincidently, the back becomes kyphotic, the skull increases in circumference and the arms are relatively shorter. *Treatment* is unavailing.

STATIC DEFORMITIES OF THE SPINAL COLUMN.

Scoliosis, lordosis and *kyphoses* are the common static deformities of the spinal column. Of these scoliosis is most frequently encountered.

Scoliosis.—Scoliosis is a lateral deviation with rotation away from the antero-posterior plane of the vertebral column.

FIG. 386.—Right dorsal scoliosis in a girl aged fifteen years. (Taylor.)

Frequency of Occurrence.—Fisher found scoliosis in 11.76 per cent. of 3000 orthopaedic cases. Whitman states that it ranks next to bow-legs in order of frequency. According to Drachman, only 1.3 per cent. of school children in Denmark were affected, while in Switzerland 24.6 per cent. were scoliotic in varying degrees. It has been stated that the condition is more common in large towns than in rural districts.

Age and Sex.—Scoliosis is an affection of the adolescent period of life. More than 50 per cent. of such cases are found in the age-period from seven to fourteen years. It is more common in girls over five years than in boys of the same age.

Heredity.—Heredity plays an important part, undoubtedly, in the etiology of a considerable proportion of scoliotics.

Normal Anatomy.—The vertebral column consists of two parts, namely, an anterior column composed of vertebral bodies, which is weight-bearing in its function, and a posterior column consisting of the neural arches, whose function is two-fold: *protection* for the spinal cord and *attachments* for the ligaments and muscles.

Physiological Curves.—The spinal column has four physiological curves: two kyphotic situated in the sacral and dorsal region, and two lordotic, in the cervical and lumbar segments. These normal curvatures vary with age, race, individual, vocation, muscular condition, etc. Although essentially hereditary in origin, they are, however, modified by muscular action incidental to standing, sitting, walking, etc. Changes are produced by these curves in the shape of the intervertebral disks. The disks in the lordotic regions become wedge-shaped and thicker anteriorly than posteriorly. These disks are compressible and the greater their thickness in any part of the spine, the greater the freedom of movement of that segment. It results, therefore, that the greatest amount of motion is possible in the cervical and lumbar segments.

Spinal Movements.—In a normal spine the movements are flexion, extension and hyperextension in the antero-posterior plane; lateral flexion in the frontal plane; and rotation on the long axis of the vertebral column.

Pathology.—In scoliosis the spine not only deviates in a lateral curvature, but it also rotates on its long axis. The different varieties of curves which are formed will be considered in the following discussion:

Pathological Curves.—Schulthess emphasizes the following factors in the production of abnormal spinal curvatures:

1. Resisting powers of the vertebral column, its shape, elasticity, firmness and tension.
2. Body-weight and alteration of its center of gravity.
3. Muscular tension and its variations.
4. Additional loading.

There are mechanical influences which act asymmetrically and are potent underlying factors in the causation of scoliosis. Structural asymmetry in the spine, limbs, or pelvis, occupational habits of movement, faulty postures or unilateral infantile paralysis are likewise etiological factors in lateral curvature of the spine. Disturbance of the normal muscular coördination in maintaining the "body balance," and a faulty attitude in the sitting posture contribute to this condition.

Clinical Features.—There are two clinical varieties of scoliosis: *Functional and structural.* In the *functional* form there are but slight structural changes which are amenable to treatment. In the *structural*

variety the anatomical changes are established in the vertebræ, disks, shoulder-girdle, ribs and pelvis.

Varieties of Curves.—When making a physical examination, a soft blue pencil should be employed to indicate the tips of the spinous processes, so that an accurate estimate of the location, extent, and type of the curvature may be made. The curves most commonly encountered are the following:

1. C-shaped curve, on the entire vertebral column and directed to the left.
2. S-shaped curve, designated right or left according to the inclination of the convexity, and denominated according to the spinal segment involved, such as right dorsal or left lumbar scoliosis.

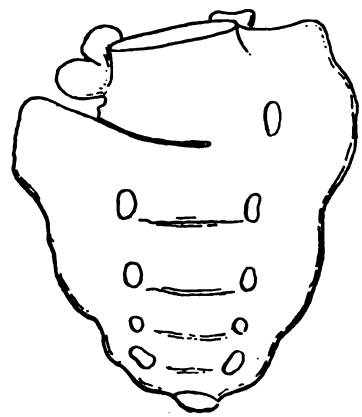

FIG. 387.—Unilateral sacralization of fifth lumbar vertebra which frequently leads to scoliosis.

3. Scoliosis with an angular projection of the spinous processes at the junction of the upper and lower curves.
4. Two or more curvatures combined.
5. Scoliosis complicated by kyphosis.

Site of the Principal Curvatures.—Most frequently curvature is located at the twelfth dorsal vertebra. Curvature to the left is the most common; this is especially true in males in whom also location of the curvature is higher than in females. Convexity to the right is most frequent at the level of the seventh cervical vertebra. Left-sided dorsal convexities, on the other hand, are more frequent in the dorsal region. Compensatory curves are less frequently produced by left-sided convexities, but are often associated with convexities to the right.

Rotation of the vertebral bodies is always toward the convexity of the curvature. The column of the vertebral bodies is curved laterally to a far greater degree than the line of the tips of the spinous processes.

Anatomical changes in the individual vertebræ are indicated as follows:

Vertebral Bodies.—Two varieties are noted, the *wedge-shaped* and the *lozenge-shaped* vertebræ. The *wedge-shaped vertebræ* are thinner in their vertical diameter on the concave side, and expanded on the convex side. The wedge shape is more marked at the point of the greatest curvature, or, in other cases, it may be more evenly distributed. The intervertebral disk is forced out toward the concave side, thus allowing, in some cases, the occurrence of synostosis of the vertebræ adjoining. The *lozenge-shaped vertebræ* are a variety less common than the foregoing wedge-shaped type. It is more marked at the junction of opposite curves, and its occurrence is, therefore, most common in S-curves.

The vertebral foramen becomes rounded in the convexity and pointed in the concavity. *The pedicles* are in a more antero-posterior plane on the convex side, and in a more transverse plane on the concave side than is normally the case. *Spinous processes:* the general direction of the spines is toward the convexity. As a rule, the arc of their tips describes a curve less marked than the curve of the bodies. The spinous process becomes twisted on its long axis and is deviated so that its tip is toward the convexity and its base directed toward the concavity. *The transverse processes* situated on the convex side are directed more posteriorly than in the normal. As a result, the vertical furrow between the transverse processes and the spinous processes is narrower on the convex side of the spinal column. *In the articular processes* a synostosis may occur at the joints and between the laminæ. Ossification of the ligamenta subflava may give rise to the latter condition. *Costovertebral articulations,* the joints between the ribs and vertebræ are more deeply and posteriorly located on the convex side. On the concave side they are situated more superficially and anteriorly.

The muscles on the concave side are affected from atrophy of disuse. Those on the convexity suffer from fibrous degeneration due to stretching. Dislocation of the muscular bundles of the latissimus dorsi occasionally occurs in a direction away from the convexity and toward the concave side, and the concavity is increased as a result. *Ligaments:* the anterior common ligament is thickened with a definite edge on its concave border. The edge directed toward the convexity is thinned to a marked degree.

Associated anatomical changes are noted as follows:

A. *Thorax.*—Striking changes are observed in dorsal scoliosis. The rib-angles form a marked posterior ridge on the convexity, while the ribs on the concavity become flattened. The mammillary region corresponding to the concavity becomes very prominent. The ribs are inclined downward on the convex side, while they extend horizontally on the concave side. One rib prominence is common, but prominence of two or three ribs may be present.

B. *Viscera.*—Marked disturbances occur in the viscera. In right-dorsal-left-lumbar curves, diminution in volume of the right lower thoracic cavity tends to the production of pleural adhesions, obliteration of the right pleural cavity with collapse of the right lung as a result. Pulmonary tuberculosis is frequent in scoliotics, causing death in a considerable percentage of cases.

The heart is overtaxed by this decrease in lung space and the circulatory disturbance is further increased by cardiac displacement and kinking of the aorta, producing right-sided cardiac hypertrophy and dilatation. *The trachea and esophagus* adapt themselves to the concavity. *The kidneys* are affected, the one on the convex side being displaced or compressed between the spine and the crest of the ilium, as a result of which degenerative changes may occur. *The liver* is pushed to the left and its left side is greatly increased in size in right lower scoliosis. *The spleen* is frequently displaced inward and often affected by pathological changes.

In the stomach depression of the pyloric end is frequently encountered, while its cardiac end becomes elevated. *The transverse colon* may become vertical in its direction, as a result of displacement of the abdominal viscera.

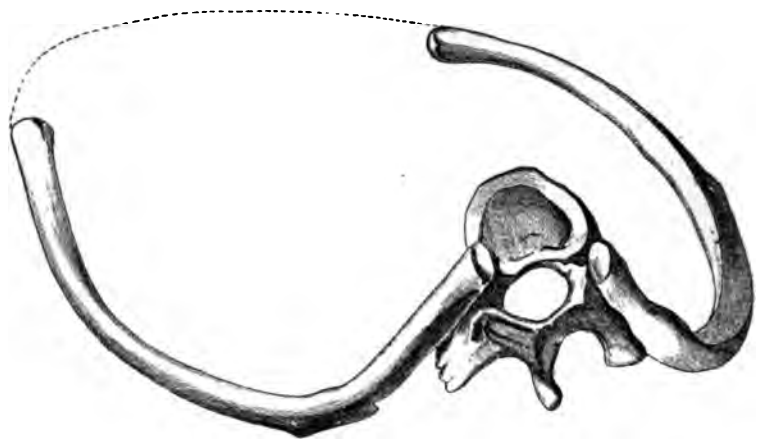

FIG. 388.—Deformity of the thorax in scoliosis. (Hoffa.)

C. *Pelvis.*—Oblique distortion of the pelvis may be present. The noteworthy deformity in the sacrum is rotation which alters the length of the oblique diameter and frequently causes obstetrical dystocia. Lateral curvature of the sacrum is rarely pronounced.

Examination.—*Family and personal history* should be carefully investigated in relation to a possible hereditary factor in the deformity. Record should be made of the state of health during infancy, more especially with reference to rickets. The date of onset of the scoliosis, and its progress, should be noted. The height and weight of the patient, his general health, liability to fatigue and his progress at school are most important data.

Physical Examination.—In a general physical examination observation should be made of the bodily nutrition, the color, evidence, if any, of neurasthenia, conformation of the chest, relative length of the legs, existence of flat feet, the posture, arrangement of clothing, etc.

Examination of the back should be made with the patient stripped to the hips. Careful note should be taken of:

1. *Cartilage of the head,* which is significant.
2. *Body outlines,* for possible asymmetry at any point. Is one hip higher and more prominent than the other? Or one flank more curved? Do the arms make equal angles with the trunk when hanging down at the side?
3. *Inequality of shoulder-level,* which cannot be readily corrected.
4. *The scapulæ,* making a comparison of the two sides.
5. Any *spinal distortion* is easily demonstrated when the hands are placed on opposite shoulders and the spine flexed anteriorly. This is the correct posture for estimating the character and the amount of curvature. The tips of the spinous processes should be indicated on the overlying skin with a soft blue pencil, and a lead tape with a straight edge or plumb line is applied to the back. The variety of the curvature (C-shaped or S-shaped) and its region and extent should be recorded in some graphic manner.
6. *Flexibility.*—When the patient bends laterally, first to the one side and then to the other, while the legs are straight, the pelvis is held fixed by the surgeon with his hands on the iliac crests. Any inequality of lateral bending indicates scoliosis, which is usually more limited toward the convex side. Further examination should consist of suspension of the patient by the Sayre head-sling, with sufficient traction to relieve the spine of any weight. If by suspension the lateral curvature is eliminated, the prognosis is good and the case is one of postural curvature, without any structural changes.
7. *Rotation* is revealed by posterior prominence of the ribs and transverse processes on the convex side. If this distortion is not apparent the patient should cross the arms, thus pulling the scapulæ forward and outward, and should bend forward with the knees straight. Rotation is then revealed by unilateral posterior projection and is largely due to lateral displacement of the vertebræ.

Examination of the thorax should be also made, noting any evidence of displacement of the thoracic and abdominal viscera, or of venous stasis.

An x-ray examination should always be made in these cases.

Scoliosiometry.—Among the numerous appliances which have been devised for recording the curvature, a simple means of making a graphic record of scoliosis is as follows: A photograph is made of the back through a thread screen placed close to the patient, the tips of the spinous processes, the angles of the scapulæ and the iliac crests, having been previously indicated with a blue pencil. A frame for standardizing photographic records of scoliosis has been devised by Bucholz and Osgood, who advocate using a stereoscopic camera, and insist that in the back or front view, the plane of the patient's back, or iliac crests, bear in successive photographs the same relation to the camera and the photographic plate. In recording rotation by forward bending, they insist, and rightly, that the bend must always be exactly to the same extent, if the photographic records obtained are to be of value.

Rotation is the most important indication of deformity and may be recorded by a direct tracing of the trunk by means of a lead tape, while the patient is in a recumbent posture. A ready and accurate means of recording the rotation is obtained by Schulthess's level indicator. The pendulum pointer of the recording apparatus stays vertical and indicates the number of degrees the levelling trapezium must be inclined to conform to the patient's back (Fig. 389).

FIG. 389.—Scoliosis. Schulthess's levelling trapezium. (Schulthess.)

Symptomatology.—The clinical features will be considered according to the stage of the deformity.

A. In the *early stage* the affection is frequently overlooked, principally because symptoms are absent. In the adolescent, the symptoms which are suggestive of incipient scoliosis are impaired vitality, aversion to prolonged exertion and a general lassitude.

B. In the *developmental stage* pain is usually absent, but may be observed in underdeveloped girls, with scoliosis at puberty. The pain varies from slight discomfort in the lumbar region to considerable distress. At this period muscular rigidity in combination with pain may give rise to some confusion with Pott's disease, in a differential diagnosis. In border-line cases, where the diagnosis is not certain, the deviation should be corrected, rest prescribed and examination made frequently until diagnosis is settled. Special difficulties in diagnosis may be presented by young girls with neuralgic pains, hyperesthetic areas, tenderness over the spinous processes or hysterical paraplegia.

If the deformity is extreme, considerable pain may be experienced, both local and general in character. When localized, it is frequently on the convex side, and in dorsal curvatures may be most marked just below the angle of the scapula. This pain is due to several factors, such as:

1. Abnormal tension on the muscles and ligaments over the convexity.

2. Pronounced deformity of the thorax and displacement of the viscera.

3. Pressure on the lumbar nerves by the last rib, and on the soft parts of the flank between the ribs and the crest of the ilium, or by the displacement of the lower ribs into the iliac fossa.

4. Pressure on the nerve roots, particularly in those cases which are of congenital origin.

General hyperesthesia from lowered vitality may be contributory to causation of pain. Pregnancy often aggravates a preëxisting scoliosis. Changes incident to senility exacerbate a previously quiescent scoliosis.

C. *Stage of Arrest.*—Scoliosis may be arrested by treatment, or it may undergo spontaneous arrest at any period. Further progression of the deformity may be inhibited by bony ankylosis with calcification of the ligaments.

D. *Stage of Improvement.*—Spontaneous improvement of a case of scoliosis depends upon a number of factors, such as age of patient when the process began, improved general health, favorable climatic and hygienic surroundings and improved muscular development. The nearer the age is to the terminal period of growth, the more favorable is the prognosis. In postural cases, spontaneous improvement is not infrequent, provided the original cause has been removed and no structural changes have occurred. Spontaneous correction of the curvature is, however, impossible in scoliosis with definite bony changes; the apparent correction in such cases is due to the formation of compensatory curves.

Classification of Clinical Varieties.—The various clinical types of scoliosis may be classified, as follows: *Total scoliosis, lumbar scoliosis, dorsolumbar scoliosis, simple primary dorsal scoliosis, cervicodorsal scoliosis* and *compensated dorsal curvatures.*

In *total scoliosis* the whole spinal column is involved in a continuous curve, with the convexity usually to the left. The pelvis is commonly oblique from the shortening of a limb. It is often encountered in early life, especially in school children, in whom it develops from abnormal sitting postures. In these cases, arrest may occur spontaneously, or the case may develop into an S-shaped curve. The amount of curvature is usually not great, the deviation rarely amounting to more than one and one-half inches. The important clinical features in total scolioses include convexity to the left shoulder, with the triangular space between the hanging arm and body greater on right side than left side; depression of right loin and right thorax with corresponding raising of same on the left side.

In *lumbar scoliosis* the curvature is commonly prominent at the second lumbar vertebra. In some instances, the spine does not return to the middle line above the lumbar region. These are the so-called "overhanging" cases. Cases of this type show curves to the right side or to the left in about an equal number of instances. Compensatory curves are frequent. Lumbar scoliosis is twice as common in females

as in males, and is more frequently seen during the age-period from twelve to fifteen years. The curve is often short, sharp and resists treatment. The principal clinical feature of this type is projection of the hip on the concave side with depression of the loin and reduplication of the skin, while on the convex side the loin is full. Lateral bending is also more free toward the concave side. About 11.5 per cent. of all cases of scoliosis are of the lumbar variety.

Dorsolumbar scoliosis composes nearly one-fifth of the total number of cases of scoliosis. The point of sharpest curvature is at the junction of the twelfth dorsal and first lumbar vertebræ. More vertebræ are involved than in lumbar scoliosis, to which it is similar in many respects, except for the absence of the sharp sacrolumbar bend. The deviation may be slight and lordosis may be present; or a severe type, such as the rachitic or paralytic, may show kyphosis. As a rule compensatory curves are not marked. The convexity is generally to the left. Rotation occurs toward the convexity at the maximum of the curve, while it is directed toward the concave side at the shoulder-girdle, with depression of the shoulder at that side. Females are far more frequently affected than males in this variety of scoliosis.

In *simple primary dorsal scoliosis* the maximum amount of curvature is opposite the sixth to eighth dorsal vertebræ in most cases. No compensatory curve takes place above or below this curve. This variety is more frequent than the lumbar and next to the dorsolumbar in order of frequency. The curvature varies within wide limits. In the severe form both rotation and kyphosis are marked. In the less severe form, lordosis produces the flat-backed type. Rotation in the severe form is extreme, and in combination with the decreased height of the trunk causes pressure on and malposition of the viscera, resulting in displacement, dilatation, and right-sided hypertrophy of the heart with consequent pulmonary embarrassment. Symptoms of pressure on the abdominal viscera are common in this type of scoliosis. Dilatation of the heart with incompetency is a terminal event in most scoliotics of this type at the age-period forty-five to fifty years.

Startling changes in contour of the trunk are noted. In right dorsal scoliosis the right side of the thorax is prominent; the right scapula is raised and oblique or horizontal in direction. The right shoulder is elevated and displaced forward. The anterior bowing of the clavicle is increased, and the right arm hangs away from the side. The right flank is flattened. The lower right ribs are approximated to the iliac crest and compression of the soft parts may produce severe pain. The angles of the ribs are more acute. The left shoulder is depressed and directed backward; the left chest is flattened posteriorly, and the left scapula is hidden, while the angles of the left ribs are diminished and the ribs are less oblique. The tips of the spinous processes are directed to the left, bringing the right transverse processes into the posterior midline in the location formerly occupied by the spinous processes. In the anterior view of the chest, the left side is more prominent than the right. The tip of the sternum is displaced toward the convexity.

The greatest diameter of the chest is the right oblique instead of the transverse, as is normally the case.

Cervicodorsal scoliosis is not common. The curve is toward the right more frequently than toward the left, and the point of greatest curvature is at the third or fourth dorsal vertebra. The clinical picture is very characteristic. The curve is short and sharp; the upper part of the trunk overhangs markedly; kyphosis is a prominent feature, and the head is thrust forward and inclined toward the concave side. The scapula on the convex side is very much elevated and prominent, and the anterior-external border of the trapezius muscle stands out as a ridge extending from the head to the shoulder. The mesial border of the scapula on the concave side may over-ride the spinous processes. The neck is shortened, the arm on the concave side hangs away from the side and rotation is very marked. The upper ribs become so prominent as to give a kyphotic appearance.

Compensated dorsal curves constitute the most frequent type of scoliosis, forming nearly one-third of all such cases. The most common combination of curves is a right-sided-dorsal-left-lumbar. It has been suggested that the important etiological factor in this particular type of curvature is the universal employment of the right hand by school children, the dorsal deformity being aggravated by the left lumbar curvature which is caused by faulty position at the desk. In the common types, the dorsal curve is the primary one except in short-legged cases. The apex of the dorsal curvature is at first located at sixth to eighth dorsal vertebræ, but changes to a lower level with increase of the distortion.

Compensated curves are usually of three types. The double and overhanging variety composes the majority of adult cases. As a rule, multiplicity of spinal curves is an index of the flexibility of the spinal column. The most frequent variety is the right-dorsal-left-lumbar which presents the following clinical features: elevation of the right shoulder, with the right scapula higher than normal and abducted away from the spinous processes, and prominence of the right hip. The triangular space between the hanging right arm and the body is greater on the right side than on the left, and is another distinctive feature of this type.

Etiology.—The etiological factor in static lateral curvatures is a spinal insufficiency. This lowered spinal resistance includes principally the spinal muscles. The ligaments, as well as the bones, are involved. The discrepancy between the load and the carrying power, as a result of which we get the deformity, has been expressed by Schanz in the following formula:

Letting B represent the load, T the carrying power and D the deformity,

$$B > T = D$$

Many forces contribute frequently to increase this defective resistance; among these are heavy clothing, adiposity, or the carrying of heavy loads; prolonged fixed occupational positions; a tilting of the

pelvis; extreme malleability of the bones, as in rickets and osteomalacia; paralysis; or muscular weakness, or disuse, from severe prolonged illness. Tubby makes the following classification of scoliosis, according to etiology:

A. *Congenital Scoliosis.*—1. Curvature arising from congenital anomaly of the spine such as portions of supernumerary vertebræ.

2. Curvature arising from congenital extraspinal anomaly, such as deficiency of ribs.

3. Due to intra-uterine malposition.

B. *Acquired scoliosis.*—1. Constitutional or idiopathic, due to general insufficiency of the spine.

2. Due to processes of bone softening:
   (*a*) Rickets.
   (*b*) A few cases traceable to osteomalacia, osteomyelitis, gumma, tubercle, injury, arthritis deformans, new growths.

3. Occupational scoliosis.

4. Static scoliosis from pelvic obliquity, which is in turn due to a large number of causes, ranging from a short limb due to coxitis to unilateral flat-foot.

5. An asymmetrical position of the trunk, from diverse causes, *e. g.*, torticollis, unequal vision or hearing, loss of one arm.

6. Associated with nerve conditions:
   (*a*) Infantile paralysis.
   (*b*) A few cases due to hysteria, sciatica, locomotor ataxia, syringomyelia, Friederich's disease.

7. Due to malformations or diseases of the soft parts, pleurisy, empyema, phthisis, heart disease, skin cicatrices from burns, and following the kyphosis due to nasal stenosis, adenoids, and enlarged tonsils.

(A) *Congenital Scoliosis.*—Congenital anomalies of the spinal column are common, particularly numerical variations, such as a reduction or increase in the number of vertebræ, unilateral sacralization of the fifth lumbar vertebra, a cervical rib, a supernumerary half-vertebra, etc. Rarely, a child may be born scoliotic without any demonstrable anomalies, or with the scoliotic associated with monstrosity of varying degree; in both of these uncommon groups, scoliosis is a definite clinical entity from birth. The usual behavior of congenital scoliosis, however, is to show a latent bone anomaly at birth without a spinal deformity, the deformity appearing at a later period.

(B) *Acquired Scoliosis.*—In this group is found the great majority of cases of scoliosis. Important factors contributing to its causation are as follows:

1. *Constitutional Weakness.*—The type of curvature is more prevalent in the adolescent period, particularly among city-bred girls of overgrown stature. Associated with weakness in the spine there is commonly a relaxation of other joints, such as flat-foot or genu valgum. The

subjects are often apathetic, weak and anemic children. Development of the musculature does not keep pace with the rapidity of growth and the changes incident to puberty. Muscular and skeletal deficiency being mutually interdependent, it is difficult to determine which is the predominating weakness.

2. *Excessive Malleability of Bones.—Rickets* may lead to scoliosis. The primary deformity in such cases is an antero-posterior deviation, developing later into a lateral curvature and ultimately into a structural

FIG. 390.—Collapse of right lung and secondary scoliosis, following empyema at the age of five years. Portions of the ribs were excised, the opening never closed and after eighteen years is still discharging. (Taylor.)

scoliosis. The common practice of carrying infants on the flexed forearm tilts the pelvis causing a total postural curvature of the spine. When completely developed, rachitic scoliosis is manifested in three leading forms, namely, lumbodorsal (or lumbar kyphotic) scoliosis; multiple curves with serious deformity of the thorax; and high cervicodorsal curvature. Other varieties of softening of the vertebræ conducing to scoliosis are osteomalacia, osteitis deformans, tuberculosis, syphilis and malignant disease. In *arthritis deformans* a generalized kyphosis precedes the lateral curvature which is severe and resists treatment.

3. *Occupations.*—The following types of workers engage in occupations which are conducive to spinal curvature:

(*a*) *Hod-carriers*, who raise the shoulder of one side to steady the load.

(*b*) *Nurse-maids*, who are accustomed to carry children with arm flexed, are predisposed to scoliosis.

(*c*) *Carpenters*, by the constant use of the right hand in pushing a plane, produce a right dorsal curve.

(*d*) *School Children.*—The soft plastic spines of school children are influenced by several predisposing factors in the school routine. Primarily *fatigue* (incident to puberty and supplemented by mental and physical strain) causes the assuming of the most comfortable position in the chair, which later becomes a fixed attitude. Monotony of routine school work, over-long confinement, lack of air and exercise, and uncomfortable and unsuitable school furniture are factors which contribute to the faulty posture. There is often a mental as well as physical factor in this type. The peculiar mental state in diffident young girls at puberty may be manifested by shyness, awkward attitudes of body, and the sense of body-balance in such individuals may be faulty.

4. *Obliquity of the pelvis* frequently causes compensatory curvature of the spine. An underlying cause of the pelvic obliquity is inequality in the length of the lower limbs. Pelvic obliquity is not always accompanied by lateral curvature of the spine, provided the muscles are in good tone and the patient keeps the upright posture. Obliquity of the pelvis is especially productive of scoliosis in weakly young girls. In the latter cases, however, attempts are made to compensate for the shortened limb by assuming an equinus position of the foot on that leg while the knee of the longer limb is flexed.

5. *Unequal vision*, particularly astigmatism, frequently causes malposition, and is an important factor in the etiology of scoliosis in school children.

6. *Unequal hearing* may necessitate torsion of the head, thus reacting on the spine.

7. *Torticollis* (of long standing) may produce a cervicodorsal curve.

8. *The loss of one arm* tends to cause an asymmetrical posture of the trunk.

9. *Neurological Affections.*—Frequently scoliosis is caused by paralysis of the intrinsic muscles of the back, among which the following conditions are etiological factors:

Anterior poliomyelitis.
Multiple neuritis.
Spastic paralysis.
Sciatica.
Progressive muscular atrophy.
Pseudohypertrophic paralysis.
Tabes dorsalis.
Friedrich's ataxia.
Syringomyelia.
Tumors of the cord and meninges.

Anterior poliomyelitis produces scoliosis in a variety of ways, such as through the deformity of a leg, paralysis of one arm, or most important of all, weakness or paralysis of the intrinsic spinal and abdominal muscles. The selective involvement of the motor nerve-cells of the anterior horns of the spinal cord, which supply the spinal and abdominal groups of muscles, is somewhat rare, except in instances where there is a very general involvement of the cord. This type of deformity is a variable one, the severity of the lateral deviation depends largely upon the posture of the patient when in the erect position. The lateral curvature diminishes during recumbency and increases in a varying degree in the erect posture, according to the severity of the paralysis. A certain amount of rotation of the vertebræ is always present; this varies with the severity of the paralysis, and but rarely reaches the same degree of rotation met with in static scoliosis. Scoliotic deformities similar to those of anterior poliomyelitis are encountered following *hemiplegia, progressive muscular atrophy,* and *pseudohypertrophic paralysis.* In *spastic paralysis,* scoliosis is commonly associated with an anterior posterior deformity.

Locomotor ataxia may, in rare cases, be complicated by scoliosis. *Syringomyelia* may be associated with spinal curvature, generally scoliotic, with a slight amount of anterior posterior curvature. The condition is usually of a moderate grade and free from pain. Scoliosis with lumbar lordosis may occasionally be a late complication of *Friedrich's ataxia.*

10. *Diseases of the Chest.—Empyema* and *Pleurisy.*—As a result of cicatrization with contracture of the affected pleural cavity, scoliosis may be produced. The convexity is directed toward the healthy side. There is very slight rotation. *Congenital heart disease* is occasionally an etiological factor in children. *Chronic pulmonary tuberculosis* by reason of fibrosis and cicatrization with contracture of the lung, has a similar action to that of empyema and pleurisy.

11. *Nasal obstruction or nasopharyngitis* long continued leads frequently to contracted thorax, kyphosis and scoliosis, in the order given.

12. *Cicatrices,* dense (and with contractures), resulting from extensive burns in the region of the upper arm and thorax occasionally cause scoliosis. Its concavity is always on the affected side in such cases.

Diagnosis.—Cases of true scoliosis must be distinguished from lateral curvature incident to Pott's disease. However, it should be realized that *caries* may supervene in simple scoliosis. A kyphosis occurring at the junction of the scoliotic curves is not necessarily tuberculous, although extreme cases may closely resemble Pott's disease.

Prognosis.—In the matter of prognosis, each case should be judged on its own merits, and viewed from many angles. The influence of the following factors must be considered:

Etiology.
Age at onset.
Sex.
Mentality.

Loss of sense of balance.
General health.
Rapidity of growth.
Occupational influences.
Type, location and amount of the curvature.
Result of treatment.

1. *Etiology.*—Curves of rachitic origin are likely to grow worse with age, the added weight increasing the distortion. Girls at the age of puberty offer a prognosis that must be tempered with several considerations, discussed above. Cases presenting remediable causes, such as myopia, occupational curves, as asymmetry in the length of the lower limbs, offer a prognosis far more promising than do cases complicated by empyema, paralysis, or pleurisy. The influence of heredity is unfavorable.

2. *The Age of Onset.*—The earlier the age at onset, the greater is the deformity. The curvature in young children, if structural, is sure to become worse. The influence on the general health, and particularly on the thoracic viscera, from pressure is an important factor. Pulmonary tuberculosis, circulatory disturbances, and the like, are in danger of being engrafted on account of the lowered vital resistance. Scoliosis in adolescents, although it may be slow in developing during childhood, tends to increase with age.

3. *Sex.*—Deformity tends to be more severe in girls than in boys, largely on account of the inferior muscular development in the former. The lowered vital resistance resulting from the establishment of the menstrual life may also be a factor.

4. *Mentality.*—The effect of an abnormal mental attitude in shy, diffident girls is many times an etiological factor. This condition is manifested by awkward postures repeatedly assumed in sitting and standing. The prognosis in such cases is unfavorable.

5. *Disequilibration*, or the loss of a sense of balance, may have an unfavorable influence on the prognosis. This sense of body-balance should, if possible, be restored by training.

6. *General Health.*—Any condition which lowers the physical resistance lessens the possibilities of correction. This is particularly true of anemia, chlorosis, dysmenorrhea and any hysterical tendency. The distortion is occasionally increased during pregnancy.

7. *Rapidity of Growth.*—Long, narrow yielding backs fall easily into abnormal curves. These cases, when growth has been rapid present an unfavorable prognosis.

8. *Occupational Influences.*—The influence of vocational factors already fully discussed, diminishes in degree with the increasing age at which the occupation is undertaken.

9. *Type of Curve.*—Total or functional scoliosis offers the best prognosis. Assuming that treatment is begun early and persistently continued, such cases may not progress to structural changes. On the other hand, they are neglected, a total C-curve may change to an S-curve. The prognosis is much more

10. *Location of Curvature.*—Lumbar curvatures are more resistant to treatment than dorsolumbar or dorsal curves. Cervical and cervicodorsal curvatures are extremely difficult to overcome, because of the impossibility of getting an efficient leverage on the vertebræ. Moreover, the physiological kyphosis of this region offers an additional handicap.

11. *The amount of deformity* is measured largely by the degree of rotation of the vertebræ. As regards the *character of the curvature,* the prognosis in rigid scoliosis of the spine in an adult can only be concerned with the *staying* of its progress; permanent correction in these cases is out of the question.

12. *Effect of Treatment.*—The prospect of cure by manipulation or by forcible treatment is in the inverse ratio to the patient's age. Total scoliosis, with little or no structural changes, can sometimes be corrected if the patient is young and the spine flexible. Congenital bony anomaly, or extensive intrathoracic disturbance, is a stubborn obstacle to any form of treatment. Paralytic scoliosis, without structural changes and with flexibility of the spine, even though associated with abdominal and spinal muscular weakness, offers a favorable prognosis as to satisfactory relief by means of the inlay-bone-graft operation, as performed by Albee for the relief of Pott's disease. This operation is fully described in the section on Tuberculosis of the Spine.

Treatment.—The treatment of scoliosis should be considered from two standpoints: that of *prophylaxis* and the *correction of the deformity.*

I. *Prophylaxis.*—The immediate elimination of any predisposing factor is urged. *Rickets* demands prompt and systemic treatment and the avoidance of faulty attitudes, particularly while the bones are in a plastic state. Parents should be impressed with the importance of a systematic observation of the child's physique for the detection of possible cryptic physical anomalies. Often the discovery of an incipient curvature is delayed until accidentally made by a dressmaker, the school-teacher or the physician.

Frequent change of daily work in school, plenty of exercise and fresh air, if possible during working hours, and particularly the avoidance of too long sitting or standing, must be observed in school life. Deformities having etiological significance must be straightway corrected. Among these should be mentioned coxa vara and genu valgum. The general health should be kept at a high standard. General muscular weakness should be overcome with well-directed exercise. Every child should be protected against mental and physical exhaustion during puberty.

II. *Correction.*—No subject in the history of orthopaedics offers a chapter more discouraging than the treatment of fully established structural scoliosis. Whatever the method followed, the prognosis in the case at hand is always a problem. "The scoliotic deformity being produced by the synchronous action of (*a*) abnormal postures; (*b*) their fixation by the constant operation of the fundamental cause; (*c*) increased by the superimposed weight of the upper trunk, shoulders, head and neck, and (*d*) loss of tone of the spinal muscles, local treat-

ment must be directed at breaking simultaneously all links of this vicious chain of events."

In all attempts at corrective treatment, careful attention should be given to such considerations as the following:

1. The *maintenance of general good health* is most important. This subject has been considered in a foregoing paragraph.

2. *Correct postures* in sitting, standing, or walking, should be taught. The patient may be put through drill-exercises which bring both arms into play. "Standing at ease," in other words, with the pelvis tilted, should never be permitted. When the legs are of unequal length, a cork sole should be applied to the shoe for the foot of the shorter leg, in order to overcome the discrepancy.

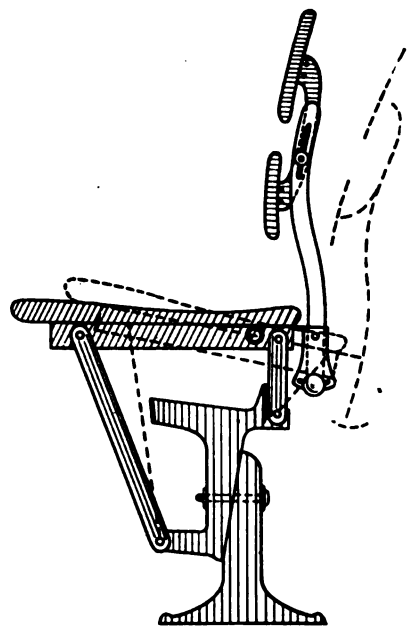

FIG. 391.—Adjustable school seat. (Miller and Stone.)

3. *Regulated periods of rest* are necessary, the purpose of recumbency being to prevent fatigue, rather than as a means of corrective treatment. Too long recumbency, as formerly advocated, is liable to have an untoward effect on the deformity; however, short daily periods of rest in the recumbent position, in conjunction with passive correction, are valuable aids to other forms of treatment. It is advisable to have the head low during sleep, with a pillow placed under the convex side, but away from the angles of the ribs. Care should be taken to prevent pressure by the pillow at the point of greatest convexity, since it is liable to increase the rotation.

4. *Exercises* and *Gymnatics*.—The purpose of exercises, well-directed, is to increase not only the flexibility of the spine, but the strength of

those muscles which are largely responsible for the contour of the spine following correction. Both active and passive exercises should be given. Many ingenious appliances have been employed in such exercises; notably among these is the apparatus of Lange. The author considers the most effective of these appliances the lateral suspension apparatus of C. F. Taylor, in which "the patient is made to grasp a pair of adjustable handle-bars attached at right angles to an upright

FIG. 392.—Self-correction by side pressure. (Taylor.)

which can be inclined away from the side of the deformity. A block is fixed on the upright so that, by adjusting the height of the handle-bars, it can be made to impinge upon the most prominent part of the convexity. With the patient hanging by the hands, and with the feet clear of the floor, considerable side-pressure is exerted upon the deformity."

Gymnastics are another form of exercise employed. The general opinion is, however, that gymnastics are of little avail in moderate or

in severe forms of scoliosis. No definite rules of exercise can be laid down, since each case demands an individual and independent study, and exercise must be prescribed to meet its special needs.

Rapid Correction of the Deformity by Manipulation and Fixation.—Treatment of scoliosis by suspension and by the application of a plaster-of-Paris jacket was first proposed in 1878, by Sayre of New York.

Albee's Method.—In the treatment of young children, from three to four years of age, with a pronounced deformity, the author uses a frame, similar to the Bradford-Whitman, on which the child is kept for a period of from six to twelve months. Webbing counter-straps (three to four inches wide) make it possible to keep up a constant corrective pressure upon the deformity. When the patient is held in this recumbent position, the results are much more rapid and complete, since the surgeon is not working against the superimposed weight of the body. The muscles and ligaments, moreover, gradually becomes more supple, yielding to the pressure, after which the child may be given one of the forms of treatment described below.

Varied and diverse opinions still exist as to the proper method for treatment of scoliosis. However, the methods given herewith are quite typical of the forms of treatment commonly used at present:

Lovett's Method.—"During the application of the jacket, the patient lies on the face on webbing strips running from end to end of a gas-pipe frame, with the legs flexed at right angles to the body. Lateral pressure is made by means of lateral webbing straps running to the sides of the frame." Lovett[1] states that greater correction of the vertebral column is secured in this position than by Abbott's method. The lateral and unrotating corrective pressure on the thorax, with the patient in this position, will prove more effective on the spine than on the thorax.

Abbott's Method.—"This method depends upon *flexion* of the spine, which tends to unlock the articular processes of the spine from one another and thus to allow greater facility of correction, especially with regard to rotation of the vertebra.

"To secure this flexion, the patient is put in an Abbott frame, which consists of a series of superimposed frames joined together by uprights, as shown in Fig. 394. To the middle of this frame is fixed a canvas hammock of trapezoid shape, so what when pulled out, one edge is tightly attached, the other loose. The patient is put in the hammock with the convexity of the back resting on the stretched part of the canvas. Then the feet are raised by a pulley, thus sharply flexing the spine. Bands running from the sides of the frame permit traction to be made on the trunk, to overcome rotation and the lateral curvature. A three-tailed bandage makes lateral traction on the prominent region of the ribs, and downward traction on the trunk. A second three-tailed bandage pulls the pelvis toward the concavity and upward. The arm on the concave side is drawn upward and forward, the other arm down

[1] Bull Dept. Surg. Harv. Med. Sch., May 20, 1915.

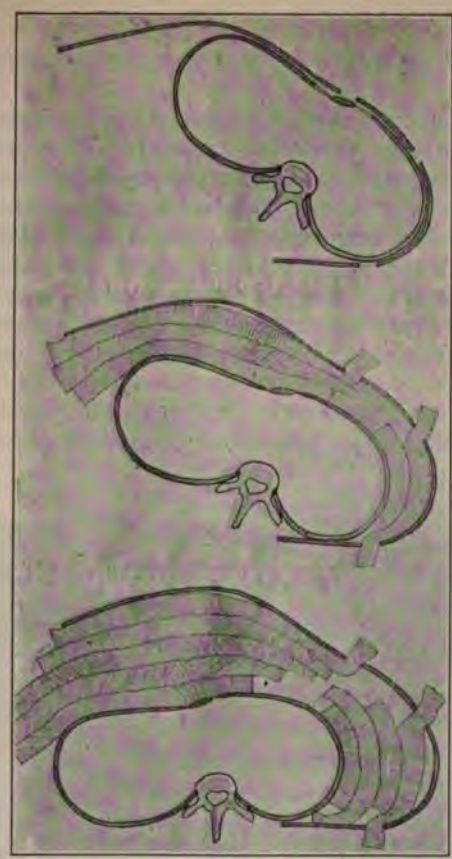

FIG. 393.—Diagram illustrating the changes which take place in the thoracic spine when felt is inserted through slits. The same changes take place in the lumbar spine by this procedure, but they are not so marked. (Abbott.)

FIG. 394.—Frame, with patient placed on it. (Abbott.)

ward and backward. If hypercorrection by this means cannot be obtained at one sitting, other trials are made. When hypercorrection is attained, the patient is put up in a plaster-of-Paris jacket. On the convex side of the curve a heavy felt pad is placed and a heavy plaster jacket applied to the patient in this position. A large window for decompression is then cut out over the concave side behind, reaching beyond the middle line of the back. Smaller rectangular windows are then cut out on the corresponding side, one on the middle line in front, the other two at the anterior and posterior axillary lines, and heavy pads are pushed in to press the thorax back into the large posterior hole in the jacket. The patient is thus held in the flexed position with one arm held away from the side, a rather unsightly and uncomfortable position."

FIG. 395.—Kleinberg's spinal brace for scoliosis, anterior view.

FIG. 396.—Kleinberg's spinal brace, lateral view.

Kleinberg's Spinal Brace for Abbott's Rotation Treatment of Scoliosis.—S. Kleinberg[1] has also devised a brace for scoliosis which he claims has all the advantages and none of the faults of the Abbott jacket (see Figs. 395 and 396). This brace is especially adapted to fixed deformities of the long single curve variety. Kleinberg applies Abbott's method in all its details, only substituting the brace for a jacket. This brace is constructed as follows:

"The brace jacket consists of pelvic and thoracic bands, three upright bars, and an accessory bar to guide the direction of the three canvas bands used to exert pressure. The pelvic band grips the pelvis firmly

[1] Jour. Am. Med. Assn., April 25, 1914, lxii, No. 17.

and is reinforced by curved bars fitted accurately over the crests of the ilia. On the side of the deformity in front, it is provided with a hinge to allow for opening of the brace during its application or removal. The thoracic band is so constructed that on the side opposite the deformity it lifts the shoulder up as high as possible, holding it forward, also, while on the side of the deformity it is interrupted in its course across the axilla, allowing the shoulder to drop down, and is held here only by a buckle and strap; on the hollow side of the axilla, it is provided with a hinge. The three upright bars connect the pelvic and

FIG. 397.—Demonstration that by rotation of the trunk superimposed on a fixed pelvis, apparent correction of a spinal curve can be produced. Dotted line, *1*, shows position of the spinous processes when the patient is turned to the left. Dotted line, *2*, demonstrates the position of the spinous processes when the patient is turned to the right. Lines *3* and *4* demonstrate the position of the angle of the ribs in these movements.

thoracic bands and are distributed as follows: one along the middle line of the back and another parallel to the posterior axillary line on the hollow side. It is essential that this bar be on a plane behind the most prominent part of the deformity, usually from three to six inches distant from the surface of the chest. The third bar is placed in front. It is fixed to the pelvic band and adjusted to the thoracic band by means of a screw-lock, so that it is easily detachable. The bar is bent to conform to the fixed chest.

"The posterior lateral and anterior vertical bars are provided with steel teeth for the attachment of the canvas bands. The accessory

bar extends upward from the pelvic band to the axilla on the side of the deformity and serves as a guide for the canvas straps, preventing them from compressing the chest.

"To the median posterior bar are attached three canvas bands. Two bands encircle the chest and are attached to the lateral posterior bar. Both, when pulled, push the ribs on the side opposite the deformity backward, tending to unrotate the spinal column; they take the place of the felt pads in the Abbott brace. One of these bands serves also by its pressure across the abdomen to maintain flexion of the body. The third band, equal in width to the area of the deformity, attaches to the anterior bar and, by hugging the deformity tightly, helps the action of the other bands.

"To make the brace, one places the patient in an Abbott jacket, being sure to adjust the pelvis and especially the shoulders as taught by Dr. Abbott and obtaining as much correction as possible. This jacket, when sufficiently hard, is cut off and filled with plaster for a torso, over which the brace is constructed. In the brace the body can be held well flexed."

Orr's Spinal Brace for Rotation Treatment of Scoliosis.—H. Winnett Orr[1] describes a brace specially designed for securing Abbott's rotation treatment. This brace consists of a wide strong pelvic band, with a straight vertical cylindrical rod extending posteriorly. Over this rod little collars are fitted, corresponding in position to the vertebræ. Each collar has a toothed edge so that it fits securely against its neighbor. These collars bear "ribs" which may be placed at any level, or in any position of rotation desired. Pressure in rotation may thus be exerted upon the ribs at any point and to any degree. Near the upper end, two of the collars, or "vertebræ," bear special pieces for supporting the shoulders. These can also be adjusted to any position desired. After all these parts have been properly adjusted, a nut is forced down against the top "vertebra" whereby the entire brace is locked firmly. The three chief advantages claimed by Orr for his brace are that positive pressure to unrotate the spine may be obtained with it; that the brace is universally adjustable for position or growth at any time, for any patient, without actual weakening of any part; and thirdly, that there is no constriction of the chest by its use.

Forbes' Method.[2]—The purpose of Forbes' method is to produce physiological scoliosis on the reverse side. To this end, Forbes fixes the pelvis and rotates the thorax by means of the arms toward the side of the deformity. The ability to produce torsion by means of the arms seems to be transmitted through them to the thorax by the serratus magnus and associated muscles. Assuming that rotation is made easier by flexion, the trunk is flexed on the pelvis. Since lordosis, as a rule, accompanies scoliosis, the lower extremities are flexed.

With patient on the Forbes frame, the desired torsion is obtained. The plaster jacket is thereupon applied. The plaster is molded from

[1] Am. Jour. Orth. Surg., Aug., 1916, xiv, No. 8.
[2] New York Med. Jour., July 6, 1912, No. 1, xcvi, 1.

the spinous processes to the angle of the ribs on the side of the deformity, and increased, if necessary; or the pressure is increased by inserting wadding between the trunk and the jacket. Forbes says that " . . . . opposing quadrants of the thorax are treated in a similar manner. Plaster opposes plaster, and window is opposite to window. In the treatment of patients by this method in Montreal, so much plaster has been cut away that it has been found necessary to reinforce the remaining plaster by irons. Treatment by torsion by this method aims at the unfolding of the deformity with the production of the physiological scoliosis on the side reverse to that of the greatest deformity.

FIG. 398

FIG. 399

FIG. 398.—A Case of paralytic scoliosis before correction and insertion of graft.

FIG. 399.—Paralytic scoliosis; same case as Fig. 398, one year after the insertion of a graft into the tips of the transverse processes of the apex of the convex side of the worse curve. The graft included the thoracic vertebræ from the fifth to the twelfth inclusive. The marked straightened condition and increased stability of the back is most gratifying.

By twist may be obtained correction without the lateral pressure which, theoretically at least, is so greatly to be deplored in the treatment of a compound deformity, of which a crushing or a narrowing of the thorax is the most important part." The Forbes jacket should be changed regularly at least every six weeks. In Forbes' hands the application of the first jacket is frequently followed by an increase in height of one inch or more.

Manipulation and Fixation Supplemented by the Use of Albee's Inlay Bone-graft in Conjunction with a Spinal Brace in Paralytic Scoliosis.—The general treatment of infantile paralysis should, in these cases, be

carried out during the initial febrile stage. This consists of restraint in bed, or on a gas-pipe frame, for the purpose of immobilization of the vertebræ of the spinal area involved. After the febrile stage has subsided, external supports, such as plaster-of-Paris corsets and metal-frame braces should be applied, together with corrective gymnastic exercises, until no further improvement can be reached by such treatment.

In the severer cases of this type, it is difficult to maintain correction of the spinal deviation by external appliances, since the spine falls into an S-curve within the brace, owing to lack of muscle-support, when the erect posture is taken. This is caused by a combination of factors, namely:

Large size of the thoracic cage.

Its motion and ever-changing *volume* due to respiration.

The fluctuation in amount of *distention* of the abdomen and its contents.

The location of the spine in the extreme posterior portion of the trunk.

After waiting for a period of not less than two years, it is for the surgeon to decide whether the muscle-weakness and the resulting curvature are sufficient to justify internal support of the spine by the implantation of a bone-graft.

Correction by bone-graft operation may be done in two ways, and must follow correction by one of the various methods described above. The operation is performed either by the same technic as is employed in Albee's operation for the relief of Pott's disease, or by inserting the graft into the tips of the transverse processes of the vertebræ on the convex side at the apex of the sharpest curve. The thoracic region is the best location for the implant, and six to eight spinous processes should be included by the graft. Theoretically the transverse processes permit a better leverage action for the correction of the lateral curvature than do the spinous processes. The presence of the dense supra- and intraspinous ligaments, however, favor the choice of the spinous process as the graft-bed. These ligaments, when sutured over the graft, help to fix it in the bed; a most important consideration.

"A lateral deviation in the spine causes a separation of the transverse processes of the convex side coincident with the approximation of the transverse processes of the concave side. Much of this lateral deformity can be readily corrected by manual force under an anesthetic. This correction causes the transverse processes of the convex side to approach each other at the same time that the transverse processes of the concave side separate. The implantation of the graft, with the spine so corrected, acts in a like manner in preventing the relapse to lateral curvature, by controlling the separation of the transverse processes of the convex side, as does the graft implanted into the spinous processes for the control of the antero-posterior deformity of Pott's disease. The graft thus embedded acts at a great mechanical advantage in that it is pulled upon lengthwise, in preventing the separation of the

transverse processes, which are arms of levers, at the same time acting as an internal fixation splint. Bearing in mind the mechanical and anatomical peculiarities of each of these two situations for the graft (the spinous and the transverse processes), it devolves upon the surgeon to select the method best suited to the exigencies of the particular case in hand."

Albee's Technic of Operation.—"A plaster-of-Paris bed with firm lateral walls should be molded (before the operation) to the back and sides of the patient's trunk, and allowed to harden while the patient is held in the corrected position. The plaster splint is then removed and laid aside until the operation has been completed. The field of operation on the back, as well as that on the leg, is prepared by the iodine method. Six to eight transverse processes (or spinous processes as the case may be) at the apex of the most acute curve, are laid bare on the convex side by a curved skin incision similar to the skin incision described in the bone-graft operation for Pott's disease. The muscles and ligaments over this and between the transverse processes are split into approximately equal halves with a scalpel. The transverse processes are split longitudinally into halves, and, at the same time, the posterior half is set over to give room for the graft. With flexible probe and calipers, the contour and length of the desired graft are determined. The tibia is flexed on the thigh and the antero-internal surface is laid bare. The flexible probe pattern is applied to this exposed tibial surface and the desired graft is outlined on the periosteum with a scalpel, its length being determined by the previous measurement with the calipers. The motor-saw is then made to cut along this periosteal outline and the graft is removed, including the full thickness of the cortex, and placed in its bed already prepared between the halves of the split transverse (or spinous) processes. While the patient is held in the corrected position, the ligaments and muscles are drawn over the graft with interrupted sutures of medium kangaroo tendon. The wound is closed by a continuous suture of No. 1 chromic gut, and a generous dressing applied. The patient is bandaged into the plaster-of-Paris bed, previously prepared. After six weeks of recumbency in this plaster bed, a well-molded plaster cast is applied to the spine, to remain on for ten or twelve weeks. Following the immediate post-operative fixation, a well-moulded plaster-of-Paris jacket, or corset-brace, is applied to those cases which need further support supplemental to the graft."

In most cases some external means of support is required on account of the unbalanced muscle-pull of the spinal and abdominal musculature and the strong lateral force brought to bear on the bone-graft. If the graft is placed in the spinous processes, per Albee's method, the post-operative care should be the same.

Lordosis.—Increase of the normal anterior curvature of the lumbar spine is practically always compensatory. Lordosis is normally greater in females than in males, particularly in Cuban women and in those with a distended abdomen from any cause, such as from pregnancy,

ovarian cysts, ascites and the like. In some types, lordosis is not compensatory, notably in spondylolisthesis and rickets, and occasionally in the lordosis of infantile paralysis.

A classification of lordosis, given by Tubby, is quoted, as follows:

1. Total.—The existence of this form is very doubtful.
2. *Partial.*—

(A) Exaggeration of curve in regions normally lordotic.
- (*a*) Compensatory to kyphosis.
- (*b*) Compensatory to increased pelvic inclination.
- (*c*) Static, *e. g.*, in abdominal obesity.
- (*d*) Paralytic.
- (*e*) Spasmodic.
- (*f*) Rachitic.

(B) Reversal of normally kyphotic curve.
- (*a*) In certain scolioses.
- (*b*) In some cases of caries of the spine.
- (*c*) Osteomalacia.

Treatment of lordosis consists essentially in treating its underlying cause rather than in the treatment of the static deformity, *per se.* In rachitic lordosis, general and specific treatment of the disease itself, must be made. Local supports should be applied for the weakened musculature. Muscular tone should be improved by means of massage, electricity and various physiotherapeutic measures.

Kyphosis.—Kyphosis is an antero-posterior deformity of the spine. In this discussion, references made to posterior spinal curvatures do not include deformities produced by such destructive lesions as tuberculosis, syphilis, malignant disease, and the like.

Tubby makes the following classification of cases of kyphosis, according to age at onset:

1. *Kyphosis of infancy,* which is generally due to feeble muscular development in conjunction with rickets.

2. *Kyphosis of Childhood.*—The *rachitic group* may be confused with tuberculous kyphosis. It should, however, be differentiated by the flabby musculature, various stigmata of rickets, the freedom of spinal motion, and the disappearance of posterior curvature when the patient is suspended from the axillæ. Furthermore, in the rachitic, hyperextension of the spine is possible to its full, normal 90 degrees. *The neuropathic type* includes kyphosis which follows poliomyelitis, pseudohypertrophic paralysis, progressive muscular atrophy, sciatica, locomotor ataxia, idiocy, and allied paralytic conditions. Kyphosis may also be associated with chest deformities, such as complicate adenoids.

3. *Kyphosis of Adolescence.*—Under normal conditions the physiological antero-posterior curve is subject to many influences such as age, sex, race, condition of the skeletal muscles, abdominal obesity, and pregnancy. With so many possible variations it is difficult to find a standard by which to compare deviations from the normal. Several forms of kyphosis in adolescents are, however, clinically recognized.

(*a*) In the "*round back*" *type*, the normal dorsal kyphosis is exaggerated and involves the cervical region which is inclined forward with the head. The pelvis is displaced forward, carrying the upper ends of the thighs with it. The thorax is inclined backward, while the abdomen protrudes forward. The condition is briefly described as *flat chest, round back* and *prominent abdomen*. This is the commonest of the adolescent types of kyphosis.

(*b*) In the "*flat back*" type, the normal dorsal kyphosis and lumbar lordosis are both decreased to a considerable degree and the spine straightened accordingly.

(*c*) The "*hollow back*" deformity is caused by increased pelvic inclination, with backward exaggeration of the sacrolumbar angle.

(*d*) The "*round and hollow back*" type is a double deformity caused by increased dorsal kyphosis with lumbar lordosis. Hyperextension of the knees frequently accompanies this variety. Next in order of frequency to the "*round back*" type, is the "*round and hollow back*," with wing-like elevation and projection of the scapulæ. All of these types are, as a rule, an indication of muscular weakness.

Treatment of Adolescent Kyphosis.—In cases of round back associated with flat chest, treatment should consist in reducing the kyphosis by means of spinal extension, appropriate exercises and gymnastics. Breathing exercises, and particularly those which will correct the anterior displacement of the shoulders and stretch the anterior portion of the shoulder-girdle are recommended. In difficult cases, forcible stretching may be necessary. For this purpose, special apparatus has been devised by Lovett. Stretching is rarely sufficient, however, and should usually be followed by correction and immobilization by means of a plaster cast, or a brace.

4. *Dorsal kyphosis of adults* is frequently caused by such factors as the following:

Muscular, or gonorrheal, rheumatism.

Arthritis deformans.

Occupation, in which a fixed, abnormal posture is maintained for the greater part of the day, as in the case of tailors or cobblers. The constant carrying of heavy loads may also be a causative factor.

Osteomalacia.

Osteitis deformans.

Bronchitis, or empyema.

Progressive muscular atrophy.

Kyphosis of *senility* is caused by retrogressive changes of the bones associated with advanced age.

TRAUMATIC AFFECTIONS OF THE SPINAL COLUMN.

Contusions.—The important feature in contusions is the damage to the spinal cord, which occasionally follows, sometimes resulting in severe hemorrhage, with disintegration of the segment of cord involved. In mild cases, with absence of hemorrhage, the patient may be temporarily incapacitated by a prolonged stiffness of the back.

Rupture of the Spinal Ligaments.—This condition is frequently present, particularly cases of rupture of the flava or subflava ligaments which bind the laminæ of the vertebræ. Many of the cases of sharp pain and stiffness of the back following acts requiring excessive physical exertion, such as the lifting of heavy weights, are probably caused by the stretching and tearing of these ligaments. Symptoms varying with degree of severity of injury may range from slight stiffness and local tenderness to rigidity and great pain. Shock, followed later by swelling, ecchymosis and hematoma, may occur. Very severe cases rarely show extensive tear of the ligaments without associated fracture

FIG. 400.—These models, which were made by a sculptor from an actual case of compression-fracture of the sixth and seventh dorsal vertebræ, are illustrative of the bone-graft technic employed in a typical case of compression-fracture without paraplegia, of this region of the spine, as well as in cases of Pott's disease, paralytic lateral curvature, etc. *A* shows the splitting of the spinous processes of the dorsal vertebræ together with the supraspinous and intraspinous ligaments in which the processes are embedded. *B* demonstrates the tibial graft implanted in the bed thus prepared, with one kangaroo-tendon suture in place to hold the split ligaments over it posteriorly. This kangaroo suture is supplemented by six or seven other sutures placed at equal intervals. The skin is later closed by continuous suture of No. 1 plain catgut, the suture-holes being "puddled" with tr. iodin and the excess immediately wiped away. The patient is kept flat on the back on a fracture-mattress for a period of six weeks. There is no necessity for fixing the patient to the mattress, except in the case of children, when the method demonstrated in Fig. 364 should be followed.

or dislocation of the vertebræ. Several cases have been reported in which the spinal cord has been seriously injured without apparent fracture or dislocation, this condition being due to hyperextension of the spine. Undoubtedly many functional nervous disorders have their origin in slight traumata of the spine.

Rest is the essential feature in *treatment*, consisting of recumbency in bed, or support of the spine by means of the plaster jacket. Massage is beneficial. Surgical treatment in these cases is limited to relief of the pressure on the cord, which may be produced either by a blood clot or by the rupture of a ligament.

Traumatic Spondylitis or Kümmel's Disease.—This condition, first described by Kümmel in 1895, is a rarifying osteitis of the vertebral bodies, but is non-tubercular. It is most common in adults. The softening and collapse of the vertebral bodies result in deformities similar to those of Pott's disease. A sprain or injury to the back may be received, which may of varying degree of severity. Frequently very little suffering is experienced and the patient soon returns to his work. It is only after a period of some weeks, or even months, that severe pain may draw attention to a rounded kyphosis, generally in the dorsal region. The vertebræ from the third to the seventh dorsal are usually attacked, although the lumbar and the cervical vertebræ may be

FIG. 401.—Roentgenogram (lateral view) of a case of fracture-dislocation of the fourth cervical vertebra upon the fifth. The injury, received in diving, was followed by paralysis of both arms, accompanied with severe pain, due, no doubt, to pressure on the nerve roots. A bone-graft operation afforded great relief in this case. (See following figures.)

affected. There is always history of injury. The condition is held by some authorities to be primarily a fracture, in which case too early use of the spine has resulted in a softening of the callus.

Symptoms.—The symptoms immediately resulting from injury are noted first. Varying intervals of rest are followed by pain at the seat of the lesion. A round kyphosis gradually develops involving usually several vertebræ. Compression of the cord in these cases is rare.

Prognosis and Treatment.—The prognosis is good. In mild cases good results are obtained by immobilizing the spine by a plaster jacket. If the case be severe, Albee's operation, as performed for Pott's disease, is recommended.

FIG. 402.—Same case as Fig. 401, showing relief of fracture-dislocation of the fourth cervical vertebra on the fith by means of a tibial graft (indicated by arrows) which was inserted into the third, fourth, fifth and sixth cervical vertebræ, by the same technic as is employed by Albee in his operation for Pott's disease. This roentgenogram was taken at time of the removal of the plaster cast in which the patient was immobilized for seven weeks following operation. Relief of paralysis of the arms was immediate, with subsidence of pain which gradually disappeared. The patient's convalescence was rapid and a considerable amount of motion was recovered, as is shown in the following figures.

FIG. 403.—Same case as Fig. 401, showing patient working at mechanical drawing, about ten weeks after plastic operation in which a fracture-dislocation of fourth cervical vertebra on the fifth was relieved and the spine immobilized by a bone graft from the third to the sixth cervical vertebræ, inclusive. In this case, rotation was unimpaired and the spine was sufficiently strong to permit the holding erect of the head for any period of time, without causing fatigue or pain. In a similar case, reported recently by a prominent physician, the spinous processes were wired together, instead of being immobilized by a bone graft. About five months after operation, the patient slipped while ascending the stairs and the muscular contraction about the neck was sufficient to pull lose the spinous processes of the vertebræ, whose substance had been severed by the destructive action of the silver wire. The dislocation of the vertebræ relapsed with pressure on the spinal cord and paralysis. The patient died a short while later, as a result of this unfortunate occurrence. In such cases, the insertion of the bone graft is a procedure based upon the physiological principles of bone growth and metabolism; the graft becomes a part of the vertebræ, themselves, and the greater the lapse of *time*, the stronger becomes the fixation. This is in striking contrast to the results *inevitably* following the use of silver wire, which exerts a destructive influence upon bone, and may eventually sever the spinous process completely.

FIG. 404.—Case of an American soldier who suffered fracture of tenth and eleventh dorsal vertebræ, as result of fall into trench. The roentgenogram shows a compression fracture of the vtertebral bodies, with destruction of the intravertebral disks, as indicated by the arrow. (See following figures.)

FIG. 405.—Same case as Fig. 404. The rontgenogram shows bone-graft immobilization of spine, eight weeks after operation for relief of compression fracture of tenth and eleventh dorsal vertebræ. A graft, indicated by arrows *A*, *B*, was taken from the patient's left tibia, and inserted into spine from ninth dorsal to first lumbar vertebræ. Relief of symptoms was rapid and the functional result was most satisfactory, as shown in the following figures.

Traumatic Neurosis.—This condition has also been termed *railway spine*, and seems dependent upon some severe accident, especially a railroad disaster for its causation. It consists of functional disturbance of the nervous system, but without demonstrable lesion of the spinal cord. Sprain of the lumbar muscles may be present, but there is no anatomical disturbance of the spine or cord, and the series of symptoms following are purely the result of autosuggestion from the mental

FIG. 406.—Same case as Fig. 404 showing result of bone-graft operation for relief of compression fracture of the tenth and eleventh dorsal vertebræ. Although the patient had suffered for a number of months prior to operation, subsequent relief of all symptoms was almost immediate, and he was discharged in excellent physical condition. Special attention is directed to the flexibility of the spine after bone-graft fixation. In spite of the seemingly paradoxical assertion, the flexibility of the spine is really greater than before the operation in which four of the vertebræ were immobilized by a tibial graft. This is due to the fact that the reflex spasm of the erector spinæ muscles above and below the lesion no longer exists, owing to the complete eradication of the pain formerly produced at the site of the crushed vertebral bodies.

image of the accident. Persons have been known to extricate themselves from a wreck, assist in aiding others injured, and to have walked some distance before a collapse occurred. From this state they have passed gradually into a condition of hypochondriasis, or even melancholia, without showing any symptoms of physical disturbance of the spine or cord. Closely related to *railway spine* are cases of *hysterical* and *neurotic spine*, which are manifestations of a morbid psychology.

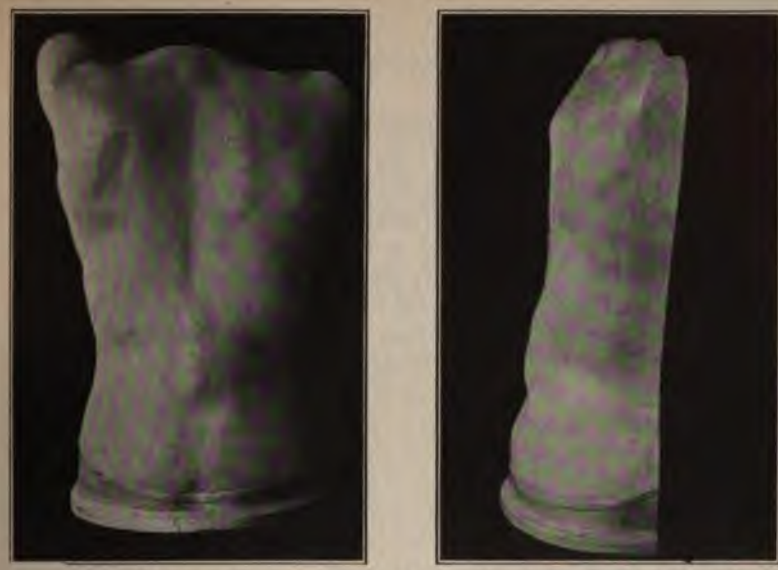

FIG. 407.—Model from an actual case of compression-fracture of the third lumbar vertebra, caused by a fall eight feet into a dugout. There was marked kyphosis of the second, third, fourth and fifth lumbar vertebræ, with moderate left scoliosis. General thickening about the vertebræ was noted, with marked lumbar spasm. The patient complained of some tenderness, and the lumbar region was held rigid upon any motion of the spine. (See following figures.)

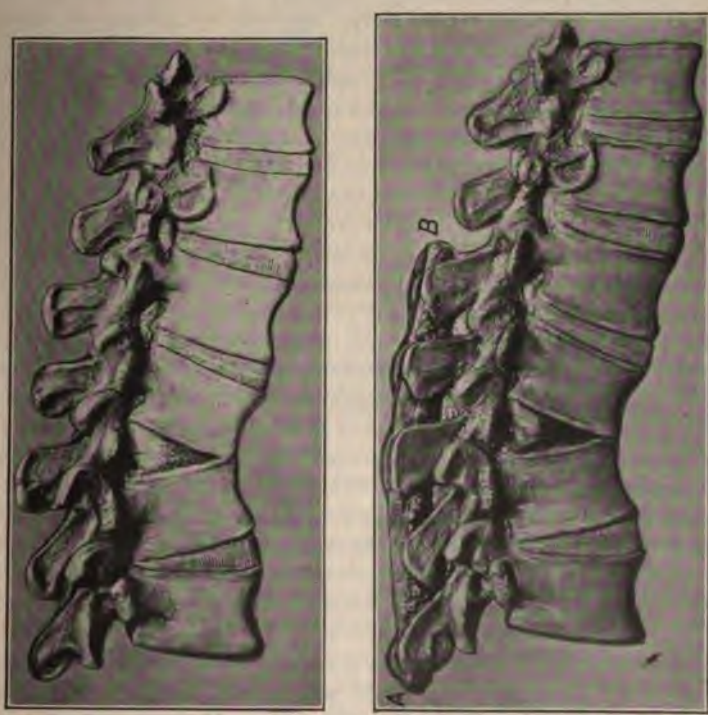

FIG. 408.—Same case as Fig. 407. Photographs of clay panels of the vertebræ modeled to show the pathological condition following the compression-fracture of third lumbar vertebra, and the relief of this condition by an inlay bone graft. The panel on the right shows the bone graft, *A–B* (which was taken from the left tibia), inlaid into the spinous processes from the first lumbar to the first sacral. The operation afforded good results; there was relief of pain and tenderness and the patient required no external spinal support of any kind, being able to walk and stoop with ease.

Treatment.—Treatment of railway spine is largely by means of psychotherapy. If contusion of the lumbar muscles be present, it should be treated by massage, friction, electricity and the like.

Coccygodynia (Coccydynia).—Coccygodynia is a painful affection in the region of the coccyx, which is much more common in females than in males. Severe cases usually give a history of a blow, or striking on the end of the spine. Long-continued horseback-riding has been known to bring it on. In some cases no cause can be found, with no manifest lesions of the cocyx. Displacement of the coccyx usually occurs either forward, backward, or laterally. Occasionally, a nodule from overgrowth of bone is to be found on the tip or side of the coccyx, and severe pain is caused by defecation, walking, or riding over rough pavements. Finger-pressure in the region elicits severe pain, which is referred to the fifth sacral and coccygeal nerves. By roentgenograph examination and by external and rectal examination, the contour and position of the bone are easily ascertained.

Treatment.—These patients are liable to be extremely neurotic. Counter-irritants are contra-indicated in the treatment on account of proximity to the gluteal cleft and the danger of setting up a dermatitis. It is essential that the bowels be kept open, and the patients should sit on an air-cushion, or lie on the side for a few weeks. The author has found high frequency electricity applied by means of special electrodes to be efficacious in the treatment of these cases.

Operation.—If conservative treatment is unavailing and pathological changes in the bone are manifest, operative interference is recommended, although operation upon a neurotic patient is strongly contra-indicated. The operation consists of excision of the whole or a portion of the bone. Incision is made near the midline, the knife being kept close to the bone in order to avoid the sacral and coccygeal nerves. After the removal of the fascia from the tip of the coccyx, the anus becomes somewhat dilated because of the attachment of the external sphincter muscle to the coccyx. This condition may be remedied and the appearance of the anus may be restored to normal by placing deep sutures from the periosteum of the sacrum through the tendinous portion of the external sphincter. Following the operation, the patient should lie on the side with the legs held together. On the third or fourth day cathartics should be administered.

Spondylolisthesis.—Spondylolisthesis is a chronic dislocation at the lumbosacral junction, or between the fourth and fifth lumbar vertebræ, as a result of which the lumbar vertebral column slips forward on the pelvis. A characteristic feature is partial spontaneous reduction of the deformity on recumbency, with recurring dislocation upon standing erect.

This disorder may be hastened by injury. Aside from the relaxation attending child-bearing, the female sex is especially prone to this condition.

Neugebauer's classification of cases of spondylolisthesis is given here, as follows:

1. Neural arches separated from bodies.
   (*a*) Defective development, congenital.
   (*b*) Traumatic form, from pressure.
2. Elongation, or sublimation, of the vertebral body from:
   (*a*) Disease.
   (*b*) Superimposed weight and pressure changes.

"*Mechanics of Production.*—The amount of displacement varies from a very slight luxation to a dislocation so extensive that the fifth lumbar vertebra slips forward and downward through 90 degrees, until its normally inferior surface is opposed to the anterior surface of the first, or first and second, sacral segments, with subsequent synostosis in this position. Thus, the normal anterior surface of the fifth lumbar vertebra faces downward, and the articulation between the fourth and fifth lumbar replaces the normal lumbosacral angle. This results in a blocking of the pelvic inlet of varying degree. The pedicles

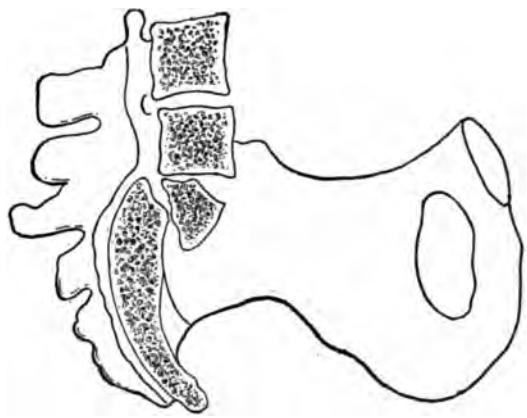

FIG. 409.—Spondylolisthesis produced by fracture of the upper segment of the sacrum and its dislocation forward and downward.

are thinned and elongated, or actually severed, the laminæ and spinous processes being forced backward. The affected vertebral body becomes wedge-shaped; its lower disk is absorbed and it may fuse with the sacrum. The sacral promontory is now replaced by the prominence of the fourth, third, or second lumbar vertebra."

Symptomatology.—The spinal column is displaced forward and downward, with a resulting displacement forward of the entire trunk. There is a compensatory decrease of the pelvic inclination, so that the symphysis pubis is on a level with the first sacral segment; sometimes on a higher plane. A vertical shortening of the trunk in the abdominal region results. The high position of the symphysis pubis makes this shortening very marked from the front view. The iliac crests stand out sharply from the loins, the decreased inclination of the pelvis produces a flattening and broadening of the gluteal region and causes a marked prominence of the posterior inferior iliac lines.

Differential Diagnosis.—Decrease in the pelvic inclination, lumbar lordosis and the vertical shortening of the trunk are almost pathognomonic of spondylolisthesis when accompanied by a marked angularity between the sacrum and the lumbar vertebræ. Congenital dislocation of the hip may be easily differentiated from spondylolisthesis.

FIG. 410.—A case of spondylolisthesis in a young man aged eighteen years following an injury in a prize fight. Deformity reduced and reduction maintained with bone graft.

FIG. 411.—Illustrating a case of the application of the bone graft for marked spondylolistheses of the lumbar vertebra on the sacrum. A strong graft removed from the tibia has fixed this segment of the spine to the sacrum correcting the lordosis and relieving all symptoms.

In dislocation of the hip, the legs, and not the trunk, are shortened; the gluteal region is prominent, but not flattened; moreover, the heads of the femora are displaced, the trochanters being above Nélaton's line. *Rickets* is differentiated by the increase of the pelvic inclination and by the infrequency of lordosis in this condition.

Correction.—All former attempts at correction of spondylolisthesis were most unsatisfactory. Treatment consisted of continued recum-

bency, with extension applied to the legs; this was followed by the application of a long plaster of Paris, or steel, spinal support which

FIG. 412.—Lateral roentgenogram of spondylolisthesis between the third and fourth lumbar vertebræ after reduction and fixation by author's spinal bone graft in spinous processes. The dislocation forward of the third lumbar vertebra on the fourth, in this male patient aged eighteen years, occurred in the boxing ring from being knocked through the ropes. Pressure on the spinal cord resulted which has been entirely relieved by the operation.

extended down over the buttocks. Such external support has been required permanently in severe cases of deformity. Instances have been reported in which laminectomies were performed. But in no cases of the above forms of treatment were results of a great or lasting value.

Application of bone-graft has solved this hitherto most difficult problem. The graft is inlaid by the same technic as that employed by

Albee for lumbar Pott's disease. (See p. 908.) With the patient in the prone position on the operating-table, the lordosis is usually corrected readily under an anesthetic. In the severer cases, the bone-graft affords the only means of securing permanent relief.

"An illustrative case is that of a young man, aged eighteen years, who had a year and a half previously, while boxing, sustained a severe injury to the lumbar spine, by being knocked against the ropes, a trauma which could readily produce such a displacement. Soon after, the patient noticed a muscular weakness, numbness and prickly sensations in the legs, when standing or walking for any length of time. These symptoms increased until he was obliged to give up his occupation. He also noticed the increasing deformity of his lumbar spine. The recumbent position relieved this symptom."

In the above case the displacement was corrected with patient in the prone position on the operating table. By means of a strong tibial graft the third, fourth and fifth lumbar spines and the first and second segments of the sacrum were firmly fixed in the corrected position. For five weeks following operation, the patient was kept on a fracture-bed. Subsequently, a plaster-of-Paris jacket, molded down over the buttocks, was worn for two months, with complete relief of symptoms.

AFFECTIONS OF THE SACRO-ILIAC JOINT.

The anatomical structure and the pathological affections of the sacro-iliac joint were held to be of relatively little importance previous to the publication, in 1905, by Goldthwait and Osgood of "A Consideration of the Pelvic Articulations from an Anatomical, Pathological and Clinical Standpoint." It had, nevertheless, been recognized that increased motion of this articulation takes place physiologically during pregnancy. It was also known that a certain amount of mobility in the pelvic articulations was normal. As pointed out by the author[1] in 1909, the sacro-iliac articulations are in every sense true joints. They have motion and all common joint structures; they are, therefore, liable to the same diseases and injuries as other joints.

Disorders of the sacro-iliac joint may be classified according to their clinical manifestations, as follows:

1. Menstrual and obstetrical relaxation of the articulation, in which the affection is due to physiological hyperemia.
2. Postural relaxation from abnormal attitudes in standing, sitting, or in a recumbent posture, particularly following prolonged post-operative recumbency.
3. Postoperative relaxation after symphysiotomy, pubiotomy, etc.
4. Traumatic relaxation.
5. Infectious sacro-iliac arthritis, from tuberculosis, or from gonorrheal, pyogenic, osteo-arthritic and rheumatic causes.

[1] Albee: Jour. Amer. Med. Assoc., October 16, 1909.

Etiological Factors.—Many factors contribute to relaxation of the joint. Among the most important causes should be mentioned:

Construction of the female pelvis, which, less strongly built than the male, is more liable to abnormal mobility, due to traumatic laceration of the ligaments. However, the greater size and strength of these articulations in the male causes the disability in this case to be more marked than in the female, when abnormal mobility does occur from traumatic or other causes.

Hyperemia and congestion incident to pregnancy and menstruation may contribute to the increased motion and relaxation of the joint.

Traumatism, such as direct blow ("sitting down hard") and severe strains following heavy lifting frequently result in relaxation of the ligaments at the sacro-iliac joint. The traumatic relaxation may be *sudden* (as in a fall from horse-back) or due to severe strain long-continued. The same influence of severe or continued strain may be noted in the relaxed sacro-iliac joint following difficult labor in which the prolonged pressure of fetal head due to disparity in size between it and the pelvic canal causes great strain on the joint. Although such obstetrical relaxation may usually be easily repaired, in non-operative cases as well as in cases following pubiotomy, owing to the strong posterior ligaments, it may occasionally persist.

Attitudes, such as prolonged dorsal recumbency or standing with extreme lordosis or "lounging" are etiological factors.

Obesity, and particularly the dragging pull of a heavy, pendulous abdomen, may cause lordosis with consequent strain of these joints.

Corsets, of the straight-front variety lead to increased lordosis, also causing pressure on the anterior part of the iliac crests, all of which tends to relaxation of the sacro-iliac joints.

Tuberculosis, in which the lesion usually extends from the sacrum as a sequel to Pott's disease of the last lumbar vertebræ. *Gonorrhea,* in which case the gonococcus in rare instances has invaded the joint in systemic infection following urethritis.

Osteomyelitis, pyogenic infection of the contiguous sacrum or ilium, may extend into the joint.

Atony of *muscles* and peri-articular ligaments and visceral ptosis favor relaxation.

Developmental peculiarities in which the etiology is undetermined and a congenital malformation may be a factor by lessening the pelvic stability or result in frictional irritation from the rubbing of the mis-shapened bone against some part of the joint during normal or abnormal motion.

Normal Anatomy.—"In 1909 the author reported the results of his researches on the anatomy of the sacro-iliac joint based upon the careful dissection of fifty specimens. It was found that each specimen presented a perfect joint, composed of all its elements such as synovial membrane and cavity, and strong, well formed capsule, all of which proved to be as constant in their size and relationships as those of any other joint."

"The antero-inferior aspect of the capsules was found to be very thin, which accounts for the fact that infection of this joint is very prone to discharge by this avenue into the pelvis and rarely through the very thick part of the capsule posteriorly; also, this part of the capsule often ruptures in symphysiotomy, and, in case of puerperal sepsis, opens the joint to infection. The lumbosacral cord passes in close proximity to the joint at its lower third, and undoubtedly is frequently involved in affections of this joint, thus explaining the presence of persistent pain in the distribution of this nerve, *i. e.*, sciatica.

"The articulation is easily opened on the autopsy table by incising the anterior part of the capsule and forcing the pelvic bones apart in front, the pubic symphysis having already been divided. Hence, the occasional interference with locomotion and permanent injury of this joint, following symphysiotomy. In the author's dissections, the interosseous ligament always separated from the ilum and never from the sacrum. The round ligament sometimes ruptured and sometimes its bony attachment. The anterior or auricular portion of each articular surface was covered with a thin plate of cartilage which was thicker on the sacrum than on the ilium. It averaged, in the fifty specimens, in its greatest length 7 cm. ($2\frac{3}{4}$ inches) and in width 3 cm. ($1\frac{1}{8}$ inches). The largest joint area of hyaline cartilage was 8 cm. ($3\frac{1}{16}$ inches), in length, and 3 cm. ($1\frac{1}{8}$ inches) in width. The smallest was 6 cm. ($2\frac{1}{4}$ inches) in length, and averaged in width $2\frac{1}{2}$ cm. ($\frac{15}{16}$ inch). The posterior irregular part is the attachment of the interosseous and round ligaments around the latter of which most of the motion occurs as about an axis. The sacrum is an inverted key to an arch suspended principally by the posterior sacro-iliac ligament. The base of the sacrum, in the upright position, projects forward beyond the articular surfaces of the ilium and has a tendency to tip down. This is prevented by the sacro-sciatic ligaments which tie the lower part of the sacrum to the ischium. Here is a great articulation, placed at the cross-roads, so to speak, between the trunk and the thighs, and mechanically imperfectly constructed to sustain sprains and injuries." (Albee, *Orthopedic and Reconstruction Surgery*).

Of the author's 50 dissections, reported above, motion was definitely elicited and measured carefully in 49 specimens. Sixteen cadavers were suspended in Walcher's position and the true conjugate diameter of the pelvis averaged an increase of 8 mm. ($\frac{1}{3}$ inch). On the living subject Walcher obtained 9 mm.

This joint will stand much abuse under favorable conditions. This is particularly true in the case of a symphysiotomy. Five cases have been reported by Edgar in which a separation of from 2 to $2\frac{1}{2}$ inches at the symphysis was followed by firm union and without manifestation of any symptoms. This articulation is, however, liable to all the affections of other joints, as has been already pointed out, and in the event of infection, the prognosis is often serious, because, (1) it is very likely to be a metastatic infection from some other part of the body, and (2)

as described above, on account of the danger of spontaneous drainage forward into the pelvis.

Pathology.—(*a*) *Relaxed Joint.*—As in other traumatic joint affections fluid from effusion may or may not be present, and the resulting condition designated "moist" or "dry." Abnormal mobility may rarely be shown by moving the ilium on the sacrum, or *vice versa*. The *x*-ray is, as a rule, of no value in arriving at a diagnosis.

(*b*) *Infectious Sacro-iliac Joints.*—1. *Tuberculosis.*—The lesion is usually unilateral, although it may occur on one or both sides. The primary focus is usually in the lateral mass of the sacrum. Frequently, the disease extends into this area from the lower lumbar vertebræ. "The synovial membrane is secondarily infected, whence the disease may spread to the articular surface of the ilium. The detailed pathological process is the same as in osseous tuberculosis elsewhere in the body, except that ichor pockets (cold abscesses) are more common than is usually the case elsewhere. Owing to the thin anterior ligaments, the focalizing point is usually forward into the pelvis. The intrapelvic ichor pocket (cold abscess) may extend outward into or beneath the sheath of the psoas, appearing in the groin, or, extending further, may point more superficially, internal to the anterior superior iliac spine, or it may pass downward and appear on the buttock through the sacrosciatic notch and in the ischiorectal fossa."

2. *Pyogenic and Gonorrheal Arthritis.*—The pathology of these lesions is the same as in any other joint. There is swelling of the periarticular tissues, which may be tender and red, together with elevation of the surface temperature. In advanced cases the joint cartilages are eroded and the joint cavity may be swollen with pus.

3. *Degenerative (Hypertrophic) Arthritis (Osteo-arthritis).*—This condition is unilateral usually, and may be characterized by fusion of the joint. In one of Albee's dissections, reported above, the anterior portion of the joint was obliterated by a bony deposit which extended into the posterior ligament.

(*c*) *Congenital Anomalies.*—Congenital absence of a portion of the pubic bones may cause relaxation of the sacro-iliac joints. It is probably true that many obscure disturbances of this joint depend upon developmental peculiarities, the exact pathology of which is, as yet, unknown. In extrophy of the bladder there is frequently absence of a considerable portion of the anterior segment of the pelvic ring. Cases in which the gait is greatly interfered with, or the symptoms sufficiently severe, may justify restoration of the defective anterior segment of the pubic arch by a bone-graft operation.

Symptoms.—Symptoms of disturbance of the sacro-iliac joint from relaxation vary greatly, but certain symptoms are practically always present. Their proper interpretation should make the diagnosis unmistakable. Limitation of motion of the lumbar spine is the most common symptom. Others are swelling, pain, abnormal mobility, peculiar attitudes when standing or walking, The following description is given by Goldthwait.

Pain.—Aside from the limitation of motion, pain, which may be localized at the seat of the disease or referred to the leg or foot, is the most important symptom. The referred pains may extend the length of the leg or may be referred to definite areas in the upper or lower leg or foot. They are definitely increased by motions which result in strain of the affected joint, but are not increased by pressure along the course of the nerves, as would be true with a neuritis. The pain is almost always worse at night, because of the strain on the pelvic joints by obliteration of the lordotic curve, which results from recumbency, but is relieved by changes of position which overcome this strain, and is prevented by postures in which this strain is not present, such as in the lateral position. In the daytime, it is not apt to be present unless the joints are strained, as may result after long sitting, standing, stair-climbing, stooping, etc. It is always worse in one leg, but may be present in both. The local pain, when present, may be referred definitely to the sacro-iliac joints, but more often to the sacral region. This is made worse by anything that results in strain of these joints, and in women is worse at the menstrual period, because of the increased mobility of the joints at that time and, consequently, the greater possibility of joint strain. Recumbency, long sitting or standing increases the pain because of the strain of these joints possible at such times.

With children (in which affections of the sacro-iliac joint are very rare) the pains usually take the form of legache or backache, rarely being acute, and while they may be present during the day and interfere with the normal activities, they are always present at night, awakening the child, and are often supposed to be growing pains or confused with the night cry and with pains met with in disease of the spine or hip.

Swelling.—At times, usually in connection with the infectious processes, the sacro-iliac joints are swollen sufficiently so that the swelling is visible and can be palpated. The character of the swelling will depend on the nature of the lesion. If tuberculous, there is usually considerable infiltration of the tissues without definite fluctuation unless the process is so far advanced as to result in abscess formation. With this there is also to be expected considerable atrophy of the buttock, and this, with the history and slow onset, is usually enough to make the nature of the process clear. With the non-tuberculous process, the infiltration is less, and there can sometimes be made out a distinct sense of fluctuation. The muscular atrophy is slight, and this, together with the more acute onset and the usual involvement of some of the other joints, should make differentiation possible.

Abnormal Mobility.—While in lesions of the pelvic joints there is almost invariably limitation of some of the motions, there is also, in certain cases, an increase of the normal motion. This increase will naturally be seen chiefly in the cases in which, as the result of long-continued strain, the joints are much relaxed. To determine this, various tests may be made. Forced hyperextension of the thighs, one

at a time, thus moving the ilia on the sacrum, may be sufficient. At other times, with the patient standing, if one hand is held over the sacrum and the pubic bones are held between the thumb and finger of the other hand, and the patient now raises first one knee, and then the other, the motion is often quite distinct. Again, if the crests of the ilia are grasped with the two hands, the thumbs resting on the sacrum, and the patient raises the legs, as above, the mobility is also often apparent. Another method is to have the patient lie down and raise first one leg and then the other with the knee straight. With one or all of these, the mobility is usually apparent, but it is to be borne in mind that while there is an abnormal amount of motion under certain conditions, there is also in these very cases, under other tests, definite limitation of motion.

Attitudes on Standing or Walking.—Disease or weakness of the sacro-iliac joints frequently results in peculiarities in the use of the body that are suggestive. When standing, the body is usually inclined away from the joint chiefly affected, *i. e.*, an inclination of the entire spine to the opposite side. In rising, the spine is usually held rigid, and the hands are frequently used for support. In stooping, the flexion of the trunk is avoided. In walking, the motions are made guardedly, if the condition is at all acute, or, if the joints are much relaxed, the gait is rolling or even waddling as the result of this pelvic instability. If the condition be acute, a long step in walking is impossible, owing to the spasm of the hamstring muscles produced when the knee is straightened with the thigh flexed. In lifting the weight with the knee bent, as in stair-climbing or rising from the sitting posture, the discomfort is increased, and the hands are frequently used for support. (It is usually painful to sit on a hard-bottomed chair, and the patient relieves himself by sitting on the buttock opposite to the affected joint.)

Limitation of Motion.—In any event, if the sacro-iliac joints are strained or diseased, motion of the body which causes strain on these joints is limited involuntarily, as is true in the disease of other joints. With the sacro-iliac joints, the limitations may show by motions of the body on the thighs or by the motions of the thighs on the body. In the first place, forward bending of the body with the knees straight will be limited if the lesion is one of any magnitude, since as soon as the hamstring muscles become tight, the motion, which up to that point has been made largely in the hip and spine, is now made by the sacro-iliac joints and the spine. When this point is reached, the spinal and trunk muscles contract reflexly to protect the irritated joint, and the motions are restricted. To determine whether this limitation of motion is due to disease of the spine or to the sacro-iliac joints, the tension of the hamstring muscles should be released, and this is the most easily accomplished by the patient being allowed to sit, and in this position the same motion tried. If the spine is involved, the limitation will be present in this test as when standing. If the sacro-iliac joints are at fault, however, the bending will be much more free, since

with the hamstring muscles relaxed, the forward bending is performed almost entirely with the hips and the spine, the sacro-iliac joints under such conditions being used only in the extremes of motion, such as are rarely made.

Diagnosis.—Absolute diagnosis is based on the symptoms and signs just given in detail, *i. e.*, the combination of *pain* localized at the seat of disturbance and referred to the leg or foot, and increased by recumbency, long sitting or standing; occasionally *swelling* (visible and palpable) at the site of the lesion; *abnormal mobility* (rarely present) of the sacrum on flexion at the hip or on forced hyperextension of the thighs; and *abnormal attitudes* on standing or walking (inclination of the spine away from the joint, rigidity on rising, absence of flexion on stooping and a rolling, waddling gait on walking); *Goldthwait's symptom* (pain referred to sacro-iliac region or to the leg of the affected side when the thigh is flexed with the leg extended). If rightly interpreted, this combination of symptoms and signs is pathognomonic of relaxation or disease of the sacro-iliac joint.

Differential Diagnosis.—Several conditions which simulate sacro-iliac disturbance, may give rise to an error in diagnosis. These are sciatica, lumbago, Pott's disease, hip disease, or disease of the ilium. The following table is taken from Albee's *Orthopedic and Reconstruction Surgery.*

Disease.	Points of resemblance.	Points of difference.
Lumbago	Pain in lower back; limitation of motion	Pain is bilateral and sharply stabbing in character; location in lumbar muscles which are tender to pressure; Goldthwait's symptom absent.
Sciatica	Pain radiating down leg; local sensitiveness to jars and manipulation	Pain confined to distribution of sciatic nerve; very uncommon in children; Goldthwait's symptom absent, but pain may be elicited over sciatic nerve.
Hip disease	Limp; faulty attitude; pain on movement of thigh and on rising	Muscular rigidity in the hip-joint; *x*-ray picture different; limitation of motion in all directions.
Lumbar—Pott's disease	Pain in back and down leg; postural peculiarities; limp	*X*-ray picture different; no pain on bimanual compression of iliac spines.
Iliac disease . . .	Local tenderness	*X*-ray picture excludes sacro-iliac disturbance; Goldthwait's symptom absent.

Treatment.—The essence of treatment is protection and support of the joint. In the case of luxation, this should be preceded by replacement of the component bones and followed by immobilization, by means of external supports, such as strapping, braces, belts, plaster jackets, etc. Should the case still remain intractible, direct fixation by bone-graft, after the Albee method, should be done. The individual treatment depends upon the extent of the lesion, and the character

of its pathology. The subject of treatment will be considered under three heads, namely: *Conservative, Operative* and *Treatment of Complications.*

Conservative treatment consists of the correction of the displacement, if one exists; the treatment of relaxation of the joint; and the treatment of the relaxation due to pregnancy.

1. *Correction of Displacement.*—Displacement of the sacrum, which is rare, may be a true *luxation* or a *subluxation. Luxation* is of very rare occurrence and is the result of severe trauma. Complete reduction must be done under anesthesia. This is followed by the application of a double plaster-of-Paris spica bandage and recumbency. *Subluxation* is not of common occurrence. It consists usually of a slight luxation backward of the upper part of the sacrum. Correction may be accomplished by the following methods:

(*a*) *Hyperextension* of the lumbar spine by a pillow beneath it.

(*b*) *The Goldthwait frame* was devised originally for the application of the plaster jacket in Pott's disease. With the flexible rods so bent as to bring pressure on the sacrum, protected by a felt pad, the body-weight forces the sacrum forward. While the patient is still on the frame in the desired corrected position, and before the steel rods are removed, a long plaster-of-Paris jacket is applied well down over the buttocks or thighs. This should be followed by recumbency.

(*c*) *Hyperextension of the lumbar spine,* while the patient is suspended, may be employed to reduce the subluxation.

2. *Treatment of sprain relaxation* should be the same as treatment of a sprain of any other joint when injury is recent. The peculiar anatomical character of the sacro-iliac joint necessitates fixation of the joint for a longer period than in other cases. Recumbency in bed with as complete fixation as possible, with a pillow under the lumbar spine, is required for three or four weeks, followed by some form of support for two or three months.

In moderate relaxation a support may be employed without subjecting the patient to the recumbent posture. Albee prefers the use of adhesive strapping with a felt pad over the sacrum as a temporary support. This strapping is described as follows:

"A thick pad of felting, measuring 5 x 6 inches, is applied to the sacrum. Two-inch adhesive straps (usually five or six are required) are made to *tightly* half-encircle the pelvis just below the anterior superior iliac spines. They should extend from the extreme anterior part of the ilium on one side around the buttocks to a similar point on the other side and carried up and down until the buttocks and lower lumbar spine are covered. The pad and strapping should be reapplied every five or six days until the symptoms are relieved, and then the wide webbing belt (described below) worn for not less than six months. After symptoms have been relieved, a short Van Winkle corset, short above, long below, well down over the buttocks, with the same sacral pad as above, and with a surcingle should be worn. This corset can be most satisfactorily made by the intelligent coöperation of the

surgeon and a competent brace maker; and several fittings should be made under the direct supervision of the surgeon."

The plaster-of-Paris jacket is not a very satisfactory type of support in these cases. If it is employed, it should come well down over the trochanters to hold the pelvis firmly and should be applied while the patient is standing with the arms raised shoulder-high and the hands holding some support. The lumbar spine should be moderately hyperextended.

FIG. 413.—Van Winkle corset support for relaxation of the sacro-iliac joint. A felt pad 5 by 6 inches in diameter and 1 to 1½ inches in thickness is shown over the sacrum with a broad surcingle over it.

The Goldthwait Spring Steel Back Brace.—Another type of support, consists of a pelvic band with two steel bar uprights for the back. These are fitted in well at the bottom so as to afford a firm pressure over the upper part of the sacrum.

A wide webbing belt attached to the extreme lower end of a long corset, in the case of women, and reinforced with light steels and with a firm pad over the sacrum frequently affords very satisfactory support.

Osgood's brace, another form of support in such cases, consists of a sacral pad with a spring steel crib which presses the pad against the sacrum. It may be also used in conjunction with woven elastic trunks (fitted about each thigh and about the buttock) for greater support.

Night supports are of great importance in these cases, for it is just as essential to support the articulation during recumbency, as when

the patient is walking about, since the pain is frequently severe at night. A hard pillow may be fitted under the lordotic curve of the lumbar spine to prevent flattening of the spine at this point; this pillow may be transferred to the side when the lateral position is assumed. In extremely stubborn cases, with great pain, a plaster-of-Paris bed may be so molded that the back, sacrum, thighs and buttocks are supported.

In cases of extreme relaxation, where no relief has been obtained from strapping or from any of the appliances mentioned above, more urgent measures are recommended. *Traction by weight and pulley* may be employed in severe cases. With the patient in the recumbent position in bed, traction is applied on the limb of the affected side, until pain subsides. If no relief is afforded by use of the weights alone, or with the simple plaster jacket, the *double plaster-of-Paris spica*, with or without weights and pulley, should be applied.

3. *Treatment of Obstetrical Relaxation.*—Although the treatment of relaxed sacro-iliac joints is the same during pregnancy and menstruation as under other conditions, several special factors should be considered. In the case of multiparous women, a *pelvic examination* should be made. Uterine fibromata and old lacerations of cervix and perineum are known to have been etiological factors in several instances of symptoms referable to the sacro-iliac joints; and their correction has been immediately followed by relief of the joint disturbance.

In treatment of *acute relaxation incident to pregnancy*, the "patient may be allowed out of bed with a pelvic support three weeks after labor, the support to be worn until two or three menstrual periods have occurred. If nursing inhibits menstruation, the support should be worn for at least three months." In relaxation associated only with menstruation, a support may be necessary for an indefinite period. In cases where the relaxation is already established prior to pregnancy, the pelvis must be supported throughout this period.

Operation.—Operative treatment is indicated if the case resists all treatment by external supports. Operation consists of fixation of the sacro-iliac joint which is secured by Albee by three operations devised by him, namely:

I. *Bridge inlay bone-graft into the sacro-iliac joint, itself*, after removal of the joint cartilage.

II. *Bridge bone-graft from sacrum to posterior wing of ilium.*

III. *Inlay bone-graft from spinal inlay graft to wing of ilium* for coexisting tuberculous disease of lumbar vertebræ and sacro-iliac joint.

I. *Inlay Bone-graft into the Sacro-iliac Joint Itself.*—This operation is indicated for non-infectious relaxation of this joint. "The joint is reached through its posterior ligaments just to the inner side of the posterior wing of the ilium. The cartilagenous surfaces of the joint with the underlying cortical bone are thoroughly removed by the osteotome and Albee's motor-burr or end-mill. The dimensions of the gutter thus formed are accurately obtained by means of compasses or inside calipers. The graft is obtained from the tibia in the manner

described in the following operation. The bone-graft measures about ½ inch in width and 2 to 3 inches in length. The graft is then driven into place by means of a mallet and Albee's bone-peg set, and requires no retaining fixation sutures. Postoperative treatment consists usually of recumbency in bed for five or six weeks, or longer."

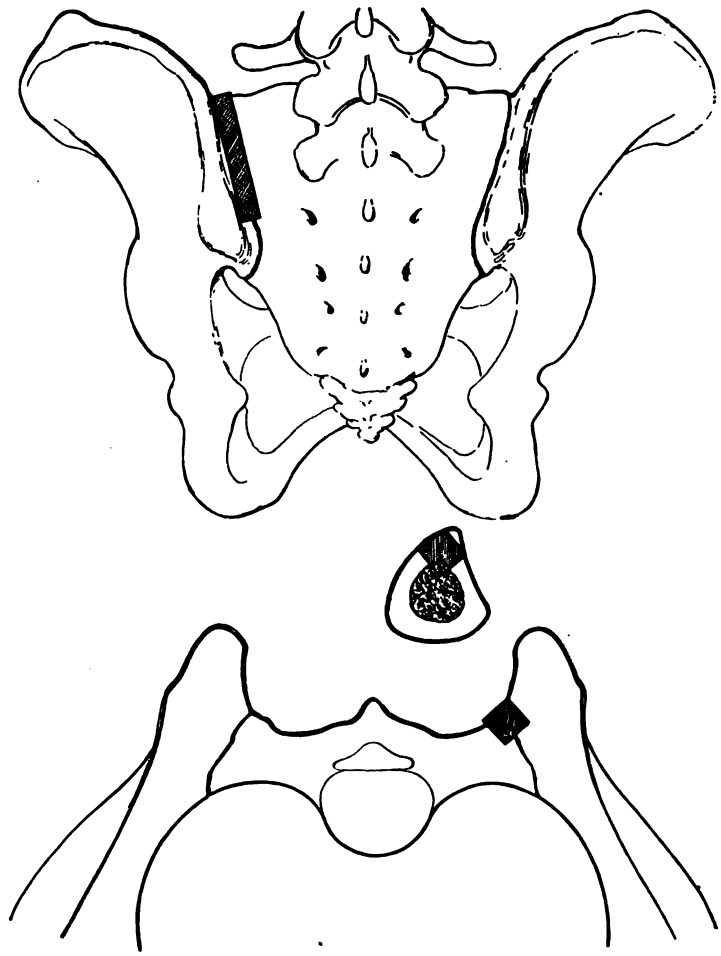

FIG. 414.—Indicates tibial inlay graft inserted into the sacro-iliac joint for support and immobilization of a relaxation of this joint, failing to be relieved by conservative treatment.

II. *Bridge Inlay Bone-graft from Sacrum to Posterior Wing of Ilium.*—This operation is indicated in tuberculosis or other destructive arthritis of this joint.

"With the patient on the face in the prone position, and both spinal and tibial fields of operation prepared, the posterior wing of the ilium and the upper portion of the sacrum are approached by a curved incision

so placed that the line of skin sutures will not directly overlie the graft. The first spinous process of the sacrum is split *en masse* with its enveloping ligaments and soft tissues, the cleft being made not vertically but at right angles to the long axis of the spine. The upper half of the split process is left attached to the sacrum and unbroken; the lower half is fractured at its base and displaced downward. On account of its small size, the first sacral spinous process may be fragmented by repeated attempts to split it in equal halves, but this interferes in no way with the ultimate result, if the fragments are left attached to the enveloping ligaments.

"The periosteum of the posterior surface of the sacrum, where the graft is to be contacted, is split in line with the cleft in the spinous process and peeled downward with the sharp periosteal elevator. The underlying bone is then scarified over a considerable area for contact with the graft.

"The mesial surface of the posterior wing of the ilium projecting toward the midline beyond the sacro-iliac joint is developed, and a cleft is made by driving a ½-inch osteotome into it in a plane parallel with the posterior sacral surface already prepared for the reception of the distal end of the graft. In making this cleft, the handle of the osteotome is pressed down as tightly as possible against the posterior surface of the sacrum. The distal end of the graft is beveled in such a way that, on being forced into its bed in the ilium, its proximal (sacral) end is tightly coapted to the posterior surface of the sacrum. The field of operation is then temporarily packed with hot saline compresses while the graft is being prepared.

"The leg from which the graft is to be removed is flexed and the site of the proposed graft exposed by a wide curved incision so placed that the line of subsequent sutures will not overlie the site of the graft removal. A bone-graft, ½ inch or more in width, is removed from the antero-internal surface of the tibia, as described under the operation for Pott's disease (see p. 908). Its distal (iliac) end is beveled on its periosteal side (which is to be the posterior side) to be driven tightly into the cleft in the ilium by means of Albee's 'bone-peg set.' As much of the marrow substance as possible is left on the graft. Numerous fragmented grafts obtained from bevelling the iliac end of the graft and from the edges of the tibial gutter are placed about the points of junction of the graft and the sacrum and ilium.

"Ligaments and soft tissues are now united over the graft by medium sized kangaroo-tendon and chromic cat-gut sutures, and the wound is closed with a continuous suture of No. 1 plain catgut in the usual manner. Postoperative treatment consists of recumbency in bed for six weeks or longer."

III. *Inlay Bone-graft from Wing of Ilium Mortised into a Previously Inserted Spinal Inlay Bone-graft, for Combined Tuberculous Disease of Lumbar Vertebræ and Sacro-iliac Joint.*—Albee's operative technic is as follows:

"The posterior superior spine, the wing of the ilium and first spinous

process of the sacrum are reached by a curved incision. The spinous processes of the last one or two lumbar vertebræ are split, with their attached ligaments, by Albee's thin wide osteotome, forming a gutter to receive the ends of the graft. A cleft is made in the posterior wing of the ilium by driving a thin osteotome, ½ inch in width, into it just anterior and mesially to its posterior superior spine (Fig. 415) and in a direction laterally from within outward. The lateral graft, which is later secured, is formed with a wedge end to be driven into this cleft, the other end being jointed by a carpenter's half-mortise to the spinal graft.

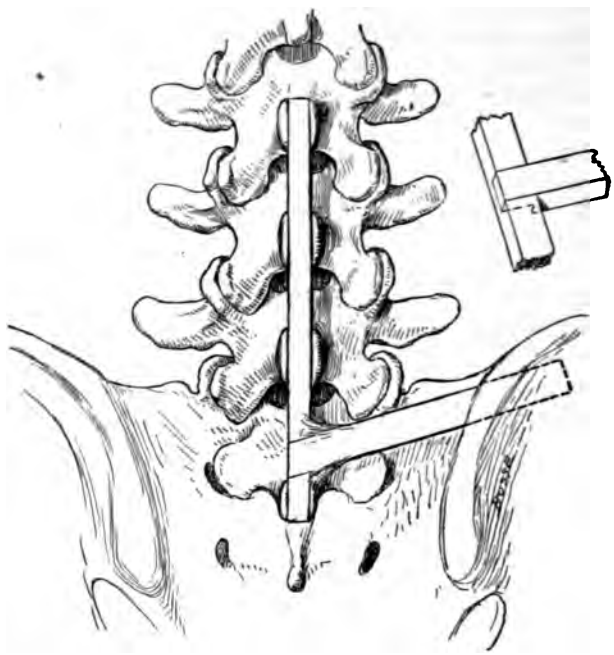

FIG. 415.—Diagram from the roentgenogram of an actual case of tuberculosis of the last lumbar vertebra and the right sacro-iliac joint. The spinal graft was inserted by the author's regular technic for Pott's disease. The graft controlling the sacro-iliac joint was joined by a carpenter's half-mortise to the spinal graft (see small upper right-hand drawing). The callus uniting the two grafts is indicated. The graft was joined to the posterior wing of the ilium by shaping it into a wedge end which was forced into a split in the ilium made by an osteotome.

"If practicable, a surface of the sacrum is denuded to furnish additional contact with the graft. The wound is packed with a saline compress and, with the patient still in the prone position, the leg is flexed and a graft of sufficient length removed from the crest of the tibia by the motor-saw, as described in the use of the bone-graft in Pott's disease, except for the just mentioned wedge end, to furnish material for the spinal graft and the lateral bridge to the ilium. The width of the graft should be three times the thickness of the cortex. The thickness should include the whole cortex, periosteum, endosteum

and a small amount of the adhering marrow. The spinal graft is placed in its prepared bed and the ligaments are drawn over it by interrupted sutures of medium kangaroo tendon."

"Before the kangaroo-tendon sutures are drawn over the lower end of the spinal graft, a segment is removed from its uppermost surface and into it one end of the lateral graft is half-mortised, the other wedge-shape end being driven into the cleft in the ilium prepared for its reception. The skin wound is closed, and the patient placed on the back on a fracture bed for a period of not less than five weeks. There should be no necessity for further mechanical treatment."

FIG. 416.—Roentgenogram of case of tuberculosis of last lumbar vertebra and sacro-iliac joint of which Fig. 415 is a drawing. *AB* is spinal graft; *CD* is graft for fixation of sacro-iliac joint.

(NOTE: When both sacro-iliac joints are affected, a lateral graft may be inlaid from sacrum to ilium on *each* side, following the method described above for unilateral relaxation.)

Treatment of Complications.—In the event of suppurative arthritis or sequestration in osteomyelitis, incision should be made, with curette-

ment and drainage. The overhanging wing of the posterior portion of the ilium should be cut away, if necessary, in order to secure adequate drainage. In case of an intrapelvic abscess pointing anteriorly into the pelvis, treatment should be given in accordance with rules laid down in works on general surgery.

FIG. 417.—Picqué's exposure of the sacro-iliac joint. (Binnie.)

FIG. 418.—Picqué's exposure of the sacro-iliac joint. (Binnie.)

Prognosis.—The prognosis varies in accordance with the pathological character of the lesion. In cases of *traumatic relaxation*, the outlook is favorable. If adequate treatment is carried out, relief should be permanent after six months to one year. The prognosis in *tuberculosis* is better in children than in adults. The outlook is more serious when there is abscess formation, especially in the presence of mixed infection. Tuberculous sacro-iliac joint disease is an extremely persistent affection. In sacro-iliac disease complicated by *gonorrhea* the chances for complete restoration of the joint and relief of symptoms is unfavorable. If the infection is very severe and bony ankylosis of the joint occurs, the pain will disappear.

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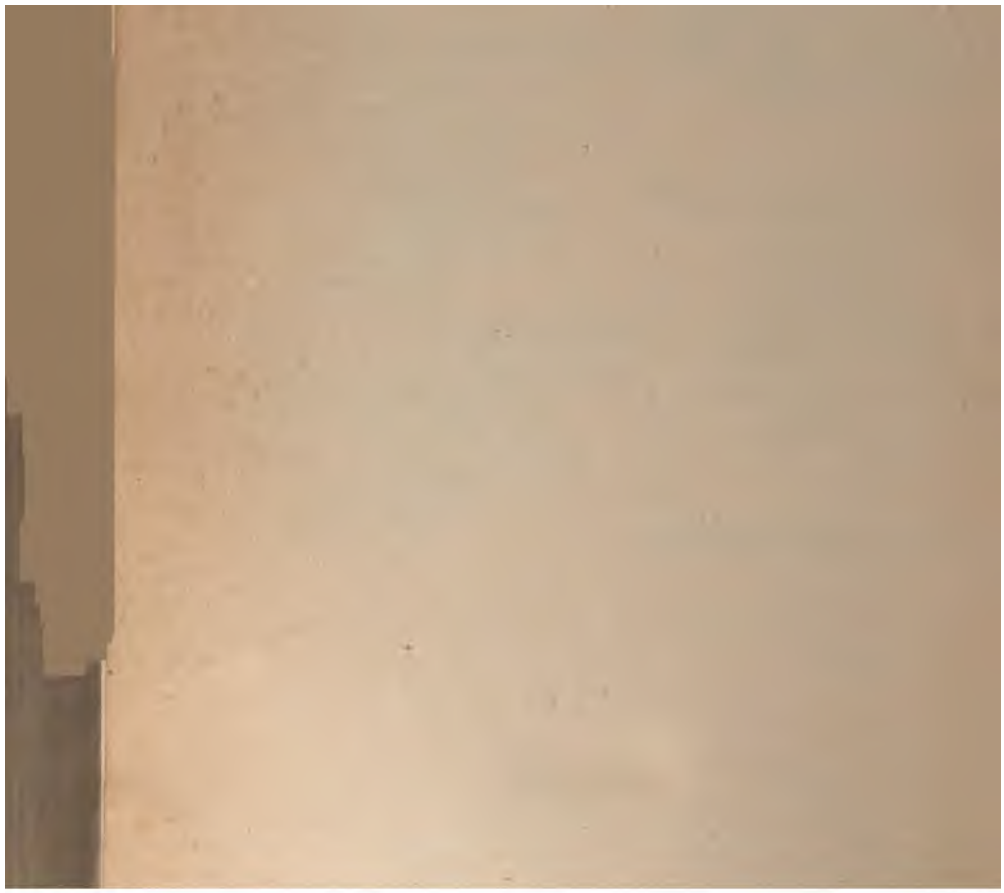

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